WORLD TRADE CENTER DNA IDENTIFICATIONS: THE ADMINISTRATIVE REVIEW PROCESS

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Abstract:

The Division of Forensic Biology at the Office of Chief Medical Examiner (OCME) in New York City is responsible for the DNA identifications of the victims of the September 11th attack on the World Trade Center (WTC). Both direct references (personal effects) and indirect references (kinship) are used and when a victim sample is linked to a reference set, the victim is identified by reviewing the reference sample's chain of custody. This has proven to be a serious challenge: in the chaos following the attacks, the collection of reference samples was not always documented completely. In addition, several agencies were engaged in the collection and handling of the samples, resulting in a wide variance of how data was recorded. Finally, the sheer volume of the process (an order of magnitude larger than an airline disaster) presents its own unique challenges. Because its software is already used by the forensic community for mtDNA analysis and the company has worked closely with the Armed Forces DNA Identification Laboratory, Gene Codes Corporation was contacted by the Division of Forensic Biology at the OCME in September of 2001 to help manage the DNA data related to WTC. In response, Gene Codes Forensics, a subsidiary of Gene Codes Corporation, made two distinct deliverables. First, it developed the Mass Fatality Identification System (M-FISys) software to manage the DNA data. Second, it designed a manual Administrative Review Process ("Admin Review") to establish and verify the chain of custody for the reference samples. The author has been at the OCME full time supervising several lab members in the Admin Review process. This paper discusses the problems faced by the Admin Review Team and the solutions designed to overcome them.

Keywords: Human identification; DNA identification; mass fatality; mass casualty incident; M-FISys; Gene Codes; World Trade Center; WTC; 9-11, 9/11; Office of Chief Medical Examiner; DMORT; VIP; Administrative Review.

I. INTRODUCTION

The Office of Chief Medical Examiner (OCME) in New York City is responsible for identifying the victims of the September 11th terrorist attack on the World Trade Center (WTC). From the perspective of human identification this tragedy presents several unique problems. Combined, these factors have created an unprecedented forensic challenge.

The first factor of note is the size of the victim population. Airline disasters, a standard reference point for mass fatality response, typically have an upper bound of about 250 passengers plus crew. With a working estimate of close to 2800 victims, WTC is an order of magnitude larger than the type of incident for which the disaster response community has first-hand experience.

Second, unlike an airline disaster, there is no definitive victim list for WTC. For this reason, WTC is considered an "open" population as opposed to a "closed" population. This has a profound implication for the identification process.

The standard of care in identifying the victims of a closed population disaster is usually to identify each victim, not every piece of tissue recovered. This allows the medical examiner to focus on the remains and methods that give the best chance of allowing the fastest identification: dental records, fingerprints, tattoos, jewelry, or visual identification. DNA tests can be conducted on these remains to confirm their identity and then on selected candidate remains to identify the victims for whom remains have not yet been identified.

But because WTC is an open population, the OCME must attempt to identify every piece of tissue recovered. Due to the high level of fragmentation (in many cases dozens of pieces have been linked to one individual) only a small portion of the remains can be rendered by traditional methods such as dental x-ray or fingerprints. Thus the majority of remains must be identified with DNA. Since even traditional methods of identification are to be confirmed with DNA, the result is that all of the remains recovered from Ground Zero will undergo DNA testing.

As of the first anniversary of the attack, the OCME had collected close to 20,000 discrete tissue samples from Ground Zero. Due to the intense pressures of the building's collapse, tissue and bone from separate victims became fused together in some cases. It thus became necessary to take two samples for DNA testing from many of the remains, one from the bone and the other from the attached muscle. Thus the number of DNA samples will exceed the number of remains recovered.

The Division of Forensic Biology at the OCME also has to contend with the fact that many of the victim samples did not yield sufficient DNA for STR analysis due to the harsh environmental conditions to which they have been exposed. New technologies have been introduced to improve the STR profiles of these remains. In addition, mitochondrial testing (mtDNA) is being deployed as well as a new approach based on the analysis of Single Nucleotide Polymorphisms, or SNPs (pronounced "snips"). It is essential that the lab be able to track the results yielded by different technologies for the same sample.

Finally, as if the staggering volume of victim samples were not enough, reference samples collected from the families of the victims had to typed and stored in such a way as to facilitate direct matches based on the victim's personal effects and indirect matches derived from kinship studies of the victim's family. Over 12,000 personal effects were collected in the two months after 9/11, of which 4500 were processed by the New York State Police and then typed by Myriad Genetics in Salt Lake City. After surveying the situation, the Division of Forensic Biology sought the assistance of an outside informatics group to assist in managing the data.

Gene Codes Corporation is a software company whose principal product, Sequencher, is used by the forensic community for mitochondrial analysis. In addition, the company has worked closely with the Armed Forces DNA Identification Laboratory (AFDIL). For these reasons the Division of Forensic Biology at the OCME contacted Gene Codes in September of 2001 for assistance in managing the DNA data for WTC.

In response, Gene Codes Forensics developed the Mass Fatality Identification System software (M-FISys, pronounced “emphasis”) to manage the victim and reference DNA profiles as well as QC samples for all of the technologies (STR, mtDNA, SNPs). Figure 1 shows an example of a direct STR match in M-FISys based on the core 13 loci, plus gender.

The first column shows three label types: RM, SP and DM (the actual label numbers have been obscured to protect the privacy of the families). The RM is the Reported Missing number and is a unique victim identifier that was introduced into the system in the spring of 2002 to replace the previous victim identifier, the P number. The number 8 in parentheses after the RM number indicates that there are eight samples linked to that victim. By clicking on the + sign, one can view the samples associated with that RM.

The SP stands for State Police and means that the associated profile is from a personal effect. The DM number refers to a discrete remain recovered from Ground Zero. The full prefix is DM01-, which stands for Disaster Manhattan 2001.

The third column is the likelihood ratio (LR), or how rare that profile is using the most conservative value from across the Asian, African-American, Caucasian and Hispanic population databases used by the OCME. In order to be used in an identification, the threshold for a personal effect was originally set to equal or greater than 1E+10. As can be seen in this example, the SP has achieved a high enough LR to allow it to make an identification.

The fourth column indicates a DM that has been identified with the letter I. For the RM row, the number in this column indicates how many remains have been linked to that RM. As can be seen, the first two RMs have 6 identified DMs. The second victim has a DM that appears to match but has not yet been identified to this case. The reason is that as DMs enter the system they may match to an already identified victim. This DM will be linked to this RM and marked with an I.

The number in the fifth column indicates how many loci report values for this profile, while the symbols in the lower corners of this box display concordance (or lack thereof) between the STR profile, the mtDNA data, and the SNP results. The Gen column displays the gender of the profile and the remaining columns are the allele calls at the loci examined (note that the remaining loci run off the edge of the screen shot). The values in these columns represent the number of Short Tandem Repeat (STR) units identified at this marker. Two numbers indicate the profile is heterozygous at that locus while a single value can indicate that the profile is homozygous or that allelic dropout has occurred. Where no measurement was recorded, the entry reads “neg”, as in the D18 locus for the DM01 sample fourth from the bottom.

The second to last row of data in Figure 1 shows an RM with 8 linked profiles, with zero identified. Upon clicking the plus sign next to the RM number it would be seen that there is an SP (a personal effect) matching to 7 DMs (remains). This would represent a new match. However, it does not mean that a new identification has been made. At this point it is not known to whom the personal effect belongs. As it turns out, finding this information is not always a straightforward task.

In the chaos following the attacks the collection of reference samples was not always documented completely. In addition, several agencies were engaged in the collection and handling of the samples, resulting in a wide variance of how data was recorded. In response to this problem, the author designed a manual Administrative Review Process (“Admin Review”) to establish the identity of a victim based on DNA reference material and then verify the chain of custody for those reference samples. In other words, Admin Review works backward from the DNA match, tracing the data through the system. Thus, in order to understand how Admin Review works, one has to know how data entered the system and made its way into M-FISys.

II. THE COLLECTION PROCESS

In of October, 2001, the author and Debra Cash (another consultant) walked through the process of handling the remains and the personal effects in order to create a process map for the Division of Forensic Biology. Figure 2 is the WTC DNA Reference Samples Process Diagram and is the earliest such version generated. Other process maps, including the handling of the disaster samples, were also developed, but are outside the scope of this paper.

This diagram provides a graphic snapshot of how the personal effects, family DNA samples, and victim information moved through the identification process. The squares without shadows are places, the circles represent databases and the squares with shadows describe the principal contents of the places and databases. The solid arrows indicate material flow (personal effects, swabs, DNA extracts) and the gray arrows indicate the flow of information (victim data, family data, STR results). To read the diagram, begin in the upper left hand corner with the Family Assistance Center (FAC) at Pier 94.

Immediately after the collapse of the World Trade Center, the New York Police Department (NYPD) set up collection points in the city to take missing persons reports and collect materials that could be used for DNA testing. Police departments outside the city established reception points in their communities and forwarded their collections to the NYPD. Within a week, the city of New York established a Family Assistance Center (FAC) on the west side of Manhattan at Pier 94 where they consolidated the missing persons intake process. Thus, the collection of reference samples and victim information is often referred to as “Pier 94” even though some of these activities took place elsewhere.

Family members, friends and co-workers went to Pier 94 to provide information about a person they thought was at WTC when it collapsed. If possible, they brought in the victim’s personal effects for direct DNA matches and gave cheek swabs for indirect DNA matches. At this point each missing person was assigned a P number and each collection of DNA reference material was given a DNA Case number.

Note that the DNA Case number was not per victim nor per item collected, it was per collection *event*. Thus if a person brought in a comb and a razor one day, both items would have the same DNA Case number. If that same person came back a few days later with a toothbrush, it would receive a different DNA Case number. However, it would be linked to the same victim via the P number. The most common items donated were toothbrushes, razors and combs.

While numerous agencies collected victim information, there are two principal sources of data from Pier 94 used by the Admin Review Team. The first is the DNA collection cover sheets used at the time personal effects and cheek swabs were donated. This single sheet of paper captures the contact information of the missing person and donor as well as their relationship.

The second source of data is the Victim Identification Program (VIP) developed by Don Bloom and Bob Shanks Jr. of the Disaster Mortuary Operational Response Teams, or DMORT. This organization is a part of the US Department of Health and Human Services and provides assistance to local medical examiners responding to mass fatality incidents. In addition to gathering family information useful in conducting a kinship analysis, VIP also captures information such as employer data, physical descriptions (including tattoos), as well as clothing and jewelry typically worn by the victim. The Admin Review Team often refers to this non-DNA data to solve difficult cases, as will be shown below.

The VIP questionnaires and copies of the DNA collection cover sheets were sent to the OCME where they were scanned into WTC Integrated, a database of all the mortuary records related to each victim. This is a browser based document viewer that was developed by the OCME’s head of Management Information Systems, Raju Venkat.

The personal effects and swabs along with the DNA collection cover sheet were sent to the New York State Police Forensic Investigation Center (NYSP FIC) in Albany. The victim’s name, date of birth, P

number and DNA Case number were written on the outside of each package. The NYSP FIC entered the information from the cover sheet and the package into a database called the BEAST, a crime lab evidence tracking system developed by the Porter Lee Corporation. A different version of the BEAST was installed at the OCME. Throughout this paper, the State Police BEAST is referred to as the "Albany BEAST" while the New York City version is called the "OCME BEAST". The State Police also generated a WTC Disaster Identifier (WDI number) for each victim.

The State Police extracted DNA from each cheek swab collected at Pier 94 and sent the extract to Myriad Genetics in Salt Lake City, Utah for testing. They coded these samples with a prefix to indicate the biological relationship of the donor to the victim, followed by the WDI number. A numeric suffix differentiated swabs among common biologic relationships such as sibling or daughter.

The NYSP FIC also selected the personal effect from each DNA collection that had the best chance of yielding a profile, extracted the DNA, and sent it to Myriad Genetics for testing. The extract was assigned an ID based on the batch number and its position in the tray. Thus SP-00125-23 is batch 125, tube number 23 (the SP stands for State Police). Since these were 24 well trays with the last well reserved for negative controls, the number in the suffix is in the fixed range of 1-23. This SP number was entered in the victim's record in the Albany BEAST.

Myriad Genetics typed the swabs and personal effects and returned the results to the State Police in the CODIS format (the core 13 STR loci plus gender). From there, the NYSP FIC downloaded the data to the OCME via the CODIS network. In the last step, the profiles were loaded into M-FISys.

For the purposes of Admin Review, there are three key points in this diagram. First, the only link between the victim name and their DNA profile is the SP number. And that connection resides only in the Albany BEAST. The second issue is that the victim information in VIP and the DNA reference samples were split apart at Pier 94 and have to be re-integrated at the OCME. Third, the interested parties who went to Pier 94 to report someone missing often came in separately. That is, the spouse of the victim would arrive at one point in time, the victim's parents would come in later, followed by a sibling or co-worker.

As a result, most victims had numerous missing persons reports filed on their behalf. Unless the information was collected in a uniform manner so that redundant records could be flagged, there was a good chance that a later intake would trigger a new entry on the missing person's list. Later, attempts at consolidating a group of records into one victim file would stall when supporting information in one report was contradicted by the information another record. The process of associating a victim name with an SP number, the integration of victim information with the DNA results, and the consolidation of records into one profile per victim has proven to be a difficult job. The sources of these difficulties are examined in the next section.

III. SOURCES OF PROBLEMS

At Pier 94 there were three principal areas where data errors occurred: information gathering, material handling and the issuance of the victim identifier. This section of the paper will examine these areas, beginning with the collection of victim data. In the following examples, all of the names used are fictional.

Information Gathering

There were six possible points of failure in the information collection process:

1. Inaccurate data from the informants.
2. Misunderstandings between informants and interviewers.
3. Uneven DNA training for interviewers.
4. Information incorrectly recorded by interviewers.
5. Lack of standardization.
6. Handwritten interviews.

1. Inaccurate data from the informant. In some cases, the person providing the information was mistaken about the data they provided. For example, an informant would give the Anglicized nickname of a co-worker who was a foreign national. In a subsequent interview, the victim's parents would provide the victim's birth name. For example, a parent might file a report on her son, Won Lei, while his co-worker might report him missing as John Lei. Both names would be added to the victim list, each with its own P number. There were similar issues with the use of nicknames, such as Catherine vs. Katie.

Surnames could also be a source of confusion. For instance, as mentioned earlier in the paper, Raju Venkat is the head of MIS at the OCME and the creator of the WTC Integrated database. But if the author filed a missing persons report for him as Raju Venkat he would be mistaken as it turns out his full surname is Venkatarum. More so than the confusion about first names, mistakes with the surnames resulted in multiple records and P numbers being generated for the same victim.

There are other examples of mistaken information that did not result in multiple records being created for one victim but such mistakes still introduced confusion into the identification process. In addition, the existence of conflicting data between records made the subsequent process of data consolidation even more difficult. For instance, some children gave conflicting years of birth for a parent. And recollections of what the victim was wearing that day proved to be unreliable in many cases.

2. Misunderstandings between the informant and interviewer. Linguistic and cultural barriers between the interviewer and the informant could result in misunderstandings. In one case there were three VIP forms filled out for an Hispanic victim. In the first two, the interviewers had non-Hispanic surnames and there were contradictions between them. The forms were also not completely filled out. The third VIP was conducted by an interviewer who was Hispanic. His form was filled out in great detail and corroborated one of the other VIP forms.

Another dimension of confusion were questions that could be interpreted in more than one way, such as "Where did the victim work?" Did that mean the name of the employer or the place where the person actually went to work? An employee of a consulting firm may have been working at a client site at WTC. In response to this question, the parent might give the name of the consulting firm while the wife would give the client's name. Later, when attempting to consolidate two records that appear to be the same victim, the Admin Review Team would be need to resolve this contradiction.

A vague question that had a more direct impact on DNA identifications was "What is your relation to the victim?". The informant might reply simply "Father" and that would be recorded on the cheek swabs. But did the informant mean he was the victim's father or vice versa? In several cases where "father" was recorded in this way, the date of birth of the donor was later than the victim's date of birth, indicating that the informant was in fact the son of the victim. This example also illustrates how data that would not appear to be useful (the donor' date of birth) was in fact quite helpful in allowing the Admin Review Team to resolve problems.

3. Uneven DNA training for interviewers. The interviewers had uneven training in DNA testing and this resulted in some misunderstandings with regard to the role of relationships in kinship studies. In some cases parents were told that donating their DNA was not necessary while in other cases DNA was collected from individuals who had no blood relation to the victim, such as a brother-in law. In addition, some interviewers were better than others in answering family questions regarding the role of genetics in identification.

4. Information incorrectly recorded by interviewer. Typographical errors are standard in any data collection system and WTC was no different. The month and day for the date of birth was sometimes reversed, names were misspelled, and phone numbers were transposed. In many cases such typos can be easily corrected. But in other cases, these "easy corrections" resulted in the consolidation of records from two victims with similar sounding last names who worked at the same employer. And in a handful of cases the donor name and the victim name were transposed in the paperwork. This was a significant

error in that it not only put the donor on the victim list, but it removed that set of reference samples from the real victim's folder.

5. Lack of standardization. Variations on how to enter common data made it difficult to later search the database and retrieve complete information on a victim. For example, police officers serving at the Port Authority of New York and New Jersey might be listed as Port Authority, PAPD, or NJ/NY Port Authority. Meanwhile, searching the database for employees of Cantor-Fitzgerald by that name would not return victims associated with employer names Cantor Fitzgerald (no hyphen), Cantor Fitz, Cantor, or CF Brokerage.

Generational identifiers such as Junior, Jnr, and Jr, were also not standardized. Again, searching the various databases for a last name with one of these terms means that names with the other terms will not be returned with the results. Thus one must know all of the possible variants to search by in order to conduct a comprehensive search.

A final example is the failure to standardize the handling of hyphenated names. For instance, a women named Sally Ritter-Dawkins was entered into the system as Sally Ritter-Dawkins, Sally Ritter Dawkins, Sally R. Dawkins, Sally Dawkins, and Sally Ritter. Searching for information on this victim by any one name would certainly result in an incomplete data set. Yet, it is not intuitively obvious that one must search by all of the variants of the hyphenated name in order to see all of this victim's data.

6. Handwritten interviews. Whenever data is keyed into a system by hand there will be typing errors. But when that data is being entered from hand writing it introduces a new level of errors based on not being able to accurately transcribe what was written. The cursive letter "m" was often mistaken as the letter "n" while the vowel "a" was sometimes rendered as an "o". In one case the lower case letters "tt" were read as an upper case "H". There are countless other examples, but the result was the same: multiple records were created for a single victim because the mistake would be made with one interviewer but not another. Later, consolidating these records would prove quite time consuming because of these transcription errors.

Levels of Accuracy and Error Estimates

The VIP form has 340 data fields. For any given record about two thirds were filled out. If we assume 99% accuracy at each of the six possible points of failure, then we have a record that is 94% accurate. For the 200 fields filled out in a given VIP, this 6% error rate means there are about 12 errors per record. Even after processing out many of the duplicate forms, six weeks after the attack there were still 3500 VIP records in the system. That is an estimated 42,000 errors.

There were 4,500 DNA collection events (amounting to over 12,000 items) in a two week period. The DNA collection cover sheet has about 40 fields of data that were routinely filled out. Again, assume 99% accuracy at each point of failure. That works out to 3 mistakes per cover sheet for a total of 13,500 errors. In point of fact, the donor is not recorded in about 250 of the collections. In another eleven collections, the name of the victim is not recorded.

In this best case scenario, there are an estimated 55,000 errors in the system. Given the unprecedented scale of the operation, the overall chaos of the immediate post 9-11 environment, and the incredible level of grief for informant and interviewer alike, it seems categorically unfair to expect 99% accuracy. If we allow for an entirely human 90% level of accuracy at each point of failure, the total errors in the system climbs to over 400,000.

Material Handling Problems

The handling of the swabs and personal effects at Pier 94 also introduced some errors into the system. On the outside of each DNA collection bag was written the victim's name, date of birth, P number and DNA Case number. Sometimes additional information was added, such as an inventory of the items or

the name of the company where the victim worked. This information was hand written, except for the DNA Case number.

Unfortunately, many of the bags had incomplete information on them or the data was copied incorrectly from the DNA collection cover sheet. If 90% of the 4500 DNA collection bags were handled correctly at Pier 94, that would mean that 450 collection bags had errors. Since there are about 2800 cases, the numbers would suggest that at least one in every six cases has a material handling problem.

The P number

Each missing person was assigned a T number if the report was filed over the telephone or a P number if it was filed in person. As previously noted, more than one person filed a missing person report on behalf of a given victim. As a result, there were cases where a victim received both a T number and a P number or multiple P numbers. This error can be managed as all of the records for a victim can be subordinated under one of the P numbers.

Unfortunately, the converse error also occurred: the same P number was issued to more than one victim in several cases. It is not clear how this happened, but one theory is that a victim would receive a T number and then a P number. Then the T number was later changed to a P number by accident. In any case, with more than one victim having the same P number, records were accidentally combined where they should have been kept separate.

With the P number corrupted, a decision was made to introduce a new victim identifier, the Reported Missing (RM) number. In the spring of 2002 the MIS group at the OCME began working with the NYSP FIC to convert all of the P numbers and WDI numbers to RM numbers. The final 500 cases were turned over to the Admin Review Team and they completed the project by the end of June.

IV. RESOLVING PROBLEMS

The Basic Process

The Admin Review Process begins when a DNA profile from a personal effect matches the DNA profile of a victim sample in M-FISys. Figure 3 outlines the main points of this process as it evolved during the course of 2002. The SP number of the personal effect in M-FISys is looked up in file downloaded from the Albany BEAST to yield the victim's name, date of birth and P number. From there, the Admin Reviewer consults another report from the Albany BEAST to gather a complete list of all the personal effects and cheek swabs on file for that victim in Albany, along with the corresponding DNA Case numbers. It is important to note that in these files and reports, the DNA Case numbers are not listed with their associated items. Thus, if the DNA Case numbers for a victim were 331 and 950 and the items collected were a toothbrush and a razor, there was no indication if the razor came from DNA Case 331 or 950.

The reviewer then turns to WTC Integrated to find that victim's DNA collection records from Pier 94. The first objective is to see if everything collected for that person at Pier 94 made it to the right folder in Albany. For example, assume there were two DNA collections at Pier 94 for a victim: Case number 126 lists a brother swab and toothbrush while the second collection, Case number 340, is a mother swab and a razor. In total there should be two case numbers in Albany (126 and 340), a mother swab, brother swab, toothbrush and a razor. If any of these items or case numbers are not listed in the victim's file in Albany, then there is a problem. Specifically, it means that these items may be in a different victim's folder and thus poses the threat of creating a mistaken identification.

The reviewer's second objective is to make sure that there is nothing extra in the victim's file in Albany. That is, they account for everything in a victim's folder in Albany by finding a corresponding collection event from Pier 94. To build on the above example, assume that a victim has two collections (126 and 340) from Pier 94 for two swabs, a toothbrush and razor. But for that the victim, Albany has three collection numbers: 126, 340, and 775. And in addition to the two swabs, toothbrush and razor, there is also a hairbrush. The hairbrush clearly goes with collection 775 and belongs to a different victim. The

reviewer would then search the Pier 94 collection database by DNA Case number 775 to identify the correct owner of the hairbrush.

The ability to screen this hairbrush from the rest of the reference samples is possible only because it is a unique item among the reference samples collected. Consider the case of a match between a victim sample and an SP number that leads to a victim file where there are two toothbrushes and DNA Case numbers, 17 and 441. Only one of the two toothbrushes was typed, but it does not indicate which one of the two. The collection records from Pier 94 for this victim show only a toothbrush under DNA Case number 17. It would appear that the second toothbrush from DNA Case 441 belongs to another victim. However, there is no way to tell at this point if the toothbrush that was typed came from DNA Case 17 (the right one) or DNA Case 441 (the wrong one).

Once the Reviewer has accounted for the material handling, they verify all of the DNA donors. That is, the Reviewers compare the name and stated relationship of the donor as recorded on the DNA collection cover sheet to the family information section of VIP to make sure that the donor had been linked to the correct victim. When VIP cannot verify the donor, the Reviewer can consult the NYPD Missing Persons' records, which contains contact logs with the family of the victim or other interested parties (such as co-workers). In many cases the DNA donor and their connection to the victim is mentioned in these records.

In trying to account for every DNA collection event as it relates to a victim and then verify every donor, one can begin to sense the impact of the errors that occurred in the information gathering process at Pier 94: spelling errors, variations in recording data (Jr. vs. Junior), transposing donor and victim names, etc. To their credit, the Reviewers have demonstrated a remarkable tenacity in searching the databases for the details necessary to account for each DNA collection and allow an identification to move forward.

By the summer of 2002, three changes had taken place that greatly aided the Admin Reviewers. First, the information linking the name of the victim to the SP number was imported into M-FISys. Second, the P number was replaced with the Reported Missing number, which is a unique victim identifier. Finally, direct access to the Albany BEAST was established, allowing the Reviewers to work with the entire data set in electronic form, replacing the printed reports.

In summary, the Admin Review Team checks all the reference samples collected for a victim, not just the one being used to make an identification. The collection records from Pier 94 are compared to the intake records in Albany. Then donors and their relationship to the victim are confirmed. If the Admin Reviewer is unable to account for all of this information the case is moved to Advanced Problem Solving.

Advanced Problem Solving

Some material handling problems could not be resolved with reference to the Pier 94 collection records and not every donor could be verified in VIP or the Missing Persons Investigation files. In these instances the Admin Review Team will flag the case as a problem and attempt to solve it by other means. The three most common methods used in advanced problem solving are kinship studies, follow-up contacts with the families and examining of the DNA collection packages.

In many of the cases where a personal effect could not be verified, there were swabs collected from family members. And while these familial samples might not have the statistics to reach the identification threshold, they could be used to establish a familial relation to a personal effect of dubious origin. Conversely, these family profiles could also be used to exclude a personal effect from a family. DNA-View by Dr. Charles Brenner and MD-KAP by Dr. Benoit LeClair were the two main software programs used to conduct these kinship studies.

The OCME has a large staff of Medico-Legal Investigators who respond to fatalities to determine if a criminal investigation is warranted. For WTC, a large number of these investigators ("MLIs") were made available to the entire agency to follow-up on challenging cases. The Admin Review Team relies heavily on the MLIs, requesting that they contact the donors to verify what reference samples were brought to

Pier 94, as well as their relationship to the victim. Out of sensitivity to the families, these contacts are made only as a last resort, when all other research methods have been exhausted.

Conversely, the families have been invited to contact the OCME via the DNA Hotline to get updates on the progress of their case. The Hotline is staffed by the same MLIs, who have access to WTC Integrated. They use these opportunities with the families to verify the DNA collection information. In addition to clearing up Admin Review problems, these dialogues with the families have had a positive impact on the quality of relations between the families and the OCME.

Some disagreements between the Pier 94 and Albany records can be resolved by pulling the original packaging and paperwork and comparing the handwriting to the entries in the databases. This is fairly labor intensive effort as it has to be done manually and the sheer bulk of these items (over 200 boxes) means they must be stored in a separate facility.

Finally, there are some cases in which the Admin Review Team has turned to non-standard sources. For example, there are numerous cases where the donor can not be verified in the records, the family cannot be contacted, and there are not enough swabs to do a kinship. In some of these cases the Admin Review Team has been able to verify the link between the donor and the victim by reference to the obituary found on one of the internet tribute sites.

V. LESSONS LEARNED

While the process of identifying the victims of WTC is ongoing at this time, it is not too early to derive some preliminary "Lessons Learned" from this experience.

Planning

As this paper has demonstrated, the gathering and recording of information about the victim is prone to errors even in the best of circumstances. If one assumes 99% accuracy at each possible point of failure it is safe to conclude that for every 100 fields of data collected, there will be at least five errors. It is also reasonable to assume that more than one intake per victim will take place, creating the need to reconcile conflicting records. In short, no intake system will be bullet-proof and an Administrative Review process to resolve these errors should be included in all disaster response planning. A few basic questions that should be resolved ahead of time include:

- Which agency will collect information from the families?
- Which agency will be responsible for the DNA identifications?
- Which agency within the Medicinal Examiner's Office will be responsible for the Administrative Review Process?

DNA Training for Interviewers

Individuals collecting the DNA reference samples should be able to explain to non-scientists how DNA is used in human identification. The interviewer should be trained in swab collection, evidence handling and chain of custody protocols. At a bare minimum, the interviewer should be able to explain the following to a grief stricken person:

- The differences between direct matches and kinship studies.
- The differences between nuclear and mitochondrial DNA testing.
- The types of personal effects that have the best chance of yielding DNA.
- The privacy policy for genetic information that is in force for the disaster.
- The limitations of DNA, particularly with regard to how fragile it is when exposed to heat and moisture.

Preview Intake Forms

Planners should preview the intake forms that will be used in their jurisdiction in the event of a mass fatality incident. Vague questions that can be interpreted in more than one way ("Where did they work?", "What is your relation to the victim?") should be re-phrased. Standard answers in the form of check boxes should be used wherever possible. And protocols for recording hyphenated last names and generational identifiers should be established. Ultimately, the best preparation is to have the agency responsible for the intake process conduct a mock interview with a group of volunteers. This will certainly identify which individuals are not ready to conduct interviews and will draw attention to questions that need to be re-worked.

Avoid Handwriting

Handwritten intakes introduce numerous transcription errors and should be avoided. Instead, the interview process should be recorded directly on a computer. Bar coding systems should be embraced where practical, especially for the collection of personal effects. In the event that forms must be filled out by hand, avoid using small font on the forms: the tight writing space encourages abbreviations and cramped writing, both of which are difficult to decipher later.

Family Follow-up

Most of the families want to be kept up to date on the identification process. During the intake process, the policy for communicating with families by the Medical Examiner's office should be explained. The families should also be told that follow-up interviews to clarify information from the initial intake may be initiated by the Medical Examiner.

Some individuals and agencies may wish to protect the families from further trauma by limiting contact with the families or withholding certain information, such as the state of the remains at recovery. In contrast, the OCME embraced a full disclosure policy and adopted a very pro-active communications strategy with the families. While some agencies were initially skeptical of this approach, the response of the family groups has been uniformly positive. It has been the experience of the OCME that despite the deep emotional wound of 9/11, the families have been remarkably resilient in their ability to absorb the facts of their respective cases and have consistently expressed their gratitude for the agency's transparency. As stated previously, the ability to work with the families in order to clarify information from their initial interview has proven invaluable in making identifications.

Human Resources

The Admin Review Team in the Division of Forensic Biology at the OCME is confronted with the daunting challenge of making as many identifications as quickly as possible without ever making a mistake. They must work with records that are incomplete and inaccurate, suffering from both data collection and material handling problems. In addition to understanding how DNA can be used for human identification, the Admin Reviewers must understand statistics, kinship studies, and lab methods. They must also be comfortable navigating a variety of data bases to collect the information necessary for an identification. In short, it is a skilled position with a tremendous amount of pressure.

On top of that, it is emotionally exhausting work. As part of the verification process, the Reviewer needs to read the family information in VIP and elsewhere. This is always a heartbreaking task. In addition, Reviewers must sometimes work with the autopsy photos, a disturbing exercise. In short, a person doing Admin Review is vulnerable to experiencing emotional trauma. The OCME has been fortunate to have access to the mental health professionals of Project Liberty and psychological support resources should be provide for Administrative Reviewers responding to future disasters.

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