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Recommendations for disaster victim identification (DVI)
of the section forensic genetics of the SSLM

Introduction

The resources required for a human identification project can vary significantly based upon the nature of the incident. It is essential to know the local, regional and federal testing facilities to determine if and which additional resources and laboratories will be needed. The scope of the incident is determined by multiple factors, including the number of victims and the extent of human remains fragmentation.

A DNA Report should not be the "identification report." A DNA Match Report is meant to be evaluated in conjunction with all the evidence related to the case. The Identification Board makes the final determination of death/identity. In cases where non-relationship (i.e. paternity) is discovered during the identification effort, this should not be disclosed to the family members.

The present recommendations are meant to provide relevant information to forensic geneticists on how to be best prepared for managing DVI situations, and provide practical guidance for each of the laboratories' tasks. Our recommendations are based on those of the *DNA Commission of the International Society for Forensic Genetics (ISFG): Recommendations regarding the role of forensic genetics for disaster victim identification (DVI)* [1], if necessary adapted to the situation of the forensic genetic laboratories in Switzerland.

Recommendation #1. Every forensic DNA laboratory should make an effort to contact the relevant authority dealing with emergency response and establish involvement in a possible mass fatality preparedness plan. Policy decisions about sample collection, scope and final goals of the effort will affect the victims' families and the work stream and should be decided as early as possible.

Remarks:
In Switzerland, the relevant authority is the DVI team Switzerland (www.dvi.ch), which is composed of criminalists, medical examiners, DNA experts, autopsy technicians, dentists, investigators of various cantonal and municipal police services, Federal Police and Government and Institutes of Legal Medicine.

Relevant contact information regarding the DNA laboratories can be found on the home page of the Swiss Society of Legal Medicine (https://www.sgrm.ch/de/allgemein/institute/)

Recommendation #2. The internal response plan needs to address throughput capacity, sample tracking, and must have names of supervisors responsible for different tasks that are updated as personnel changes.

Remarks:
In order to be best prepared, each laboratory should internally address recommendation #2. The local laboratory is responsible for the DNA identification process. If this situation exceeds the current lab capacity, other DNA laboratories should be contacted for help in this matter and the leading laboratory can change according to the circumstances.

Recommendation #3. Several sample types for DNA testing should be taken at the earliest possible stage of the investigation provided traceability is guaranteed. Samples must be collected from each body or recognizable body part, even if identity is already established. Proper storage must be assured.

Remarks:
The DNA laboratory should be contacted by the medical examiners about the post-mortem sample collection. Post-mortem sample collection can follow Table 1 [1]. Even if a victim has already been identified by other means, a DNA sample should be taken for body part association or exclusion purposes, as well as for the identification of other missing relatives.

Table 1
Post-mortem sample collection

Condition of body	Sample to be collected
Not decomposed, whole body	Blood (on FTA card or swab) and buccal (mouth) swabs
Not decomposed, fragmented	If available, blood And Deep red muscle tissue ($\sim$1.0 g)
Decomposed, whole bodies and fragmented remains	Long compact bone samples (cut 4–6 cm, using window cut without separating the shaft) And/or Healthy teeth without fillings (molars preferable) And/or Any available bone ($\sim$10 g, if possible; dense cortical bone preferable)
Severely burnt bodies	Any of the samples above Or Swab from inside the urinary bladder (see Ref. [32])

Recommendation #4. Multiple direct references and samples from first-degree relatives should be collected for each missing person. Scientists with a background in genetics should be available for training or for consultations in the family liaison group.

Remarks:
Ante-mortem sample collection should follow Tables 2-4 [1]. First degree relatives should be preferred. Buccal swabs or FTA cards (saliva or blood) are the recommended type of sample to be collected for the familial reference samples. It is important to keep in mind that a relationship as understood by the family might not be biological (e.g. an adopted child or an excluded paternity).

Table 2
Preferred family reference samples

Both parents
One parent, spouse and children
Children and spouse
One parent and sibling
Siblings (two or more)
Known identical twin

Table 3
Effectiveness of various combinations of relatives based on kinship index simulation (adopted from Ref. [9])

Family references	Probability of identity (mean posterior probability at 10% prior) (%)
One full sibling	92.1
Sibling and aunt (or uncle)	94.4
Sibling and two aunts (or uncles) from same side of the family	97.8
Sibling, aunt, uncle from different sides of the family	99.8
Sibling and half sibling	98
Sibling and two half siblings (all sharing the mother)	99.4
Two siblings	99.91
One parent	99.9
Sibling and parent	99.996
Father and one maternal half sibling	99.95
Father and two maternal half siblings	99.996
Father and maternal aunt	99.993
Three grandparents	96.7
Four grandparents	99.99
Three grandparents and sibling	99.994

Table 4
Direct reference classification

DNA quality	Commonly available	Might be available
Good sources of DNA	Tooth brushes	Samples from a bone marrow donor program, blood cards from PKU newborn screening,
	Electric and manual razors	National biobanks, criminal databases,[a] paternity testing labs,[a] reference samples from military personnel[a]
	Hair brushes and combs	Other clinical blood or serum samples
		Sperm bank samples
		Dried umbilical cord
		Paraffin embedded pathology specimen
Fair sources of DNA	Combs	Cervical smears
	Lipsticks, deodorant sticks	Fingernail clippings
	Pillowcases	Cigarette butts
	Used cups, drinking glasses	Pipe
	Used underwear	Mouth piece, mouth guard
		Motorcycle and other sport helmets—caps and hats
		Inner clothing items (bra, t-shirt, socks)
		Ear plugs, ear phones
		Eye glasses
		Pen with teeth marks
		Mailed envelopes or postcards
Poor sources of DNA	Jewelry	Baby hair
	Wrist watches	Dentures
	Outer clothing	Hair rollers
	Towels	Trimmers, scissors, nail files
	Shoes	
	Hair bands or ear muffs	

[a] Compatible genetic profiles may be available.

Recommendation #5. DVI DNA testing should only be performed by laboratories with demonstrated successful capabilities and continuous experience with these specified sample types.

<u>Remarks:</u>
No further remarks. All the Swiss forensic DNA laboratories are accredited under ISO 17025 and are experienced in identifying unknown bodies.

Recommendation #6. The set of loci to be analyzed has to be identified as soon as possible in concordance with the scientific community in the countries mostly involved. A minimum of 12 independent loci should be selected as standard set, but an even greater number of loci is preferred.

Remarks:
A minimum of 16 independent loci (plus Amelogenin) shall be used, but the analysis of 23 loci (plus Amelogenin) should be aimed for whenever the sample quality allows it. As with other multiplex kits, the laboratories must be aware of possible concordance issues between alternate primer pairs.

Recommendation #7. All allele calls and all candidate matches have to be reviewed thoroughly. Composite DNA profiles can be generated if derived from the same specimen and consistent for overlapping loci. The duplication policy should consider the logistics and circumstances of the mass fatality incident.

Remarks:
Duplicate typing of remains and reference samples is required.

Recommendation #8. If the standard autosomal STR typing fails to give sufficient information, additional typing system such as mtDNA, Y-chromosomal STRs, or SNP markers may be used in selected cases.

Remarks:
A minimum of 23 Y-STR loci should be used as a standard.

Recommendation #9. A centralized database is required for all data comparison. Electronic upload is recommended to avoid transcription errors.

Remarks:
The leading laboratory decides and provides the template/format for the transmission of DNA profiles. To speed up the process of data collection, a data format should be defined and made available by each laboratory.

Recommendation #10. Especially if multiple family members are involved, DNA-based identification should whenever possible be anchored by anthropological and/or circumstantial data, a second identification modality, or multiple DNA references.

Remarks:
No further remarks.

Recommendation #11. In DVI work, DNA statistics are best represented as likelihood ratios that permit DNA results to be combined among multiple genetic systems or with other nonDNA evidence. Likelihood ratio thresholds should be determined for when DNA data alone can suffice for an identification; this will be based on the size and circumstances (e.g. closed versus

open) of the event. All evidence and/or circumstances should be checked in making an identification, even if DNA provides the primary or sole evidentiary factor.

Remarks:
We use and report the likelihood ratio in the comparison process. For this process, appropriate and validated biostatistical software [2], as well as training, are required. The forensic DNA expert, who is part of the Reconciliation team, enters the likelihood ratio in the DVI Interpol identification report for presentation to the Identification Board. The Identification Board is a group of experts that discuss and verify proposals submitted by the Reconciliation Team. The Board makes final decisions regarding the identification of given victims and certifies these decisions on the DVI documentation.

A database that reflects the allele frequency distribution of the pool of potential victims should be chosen to determine the likelihood ratio. For example, if most victims are from Switzerland, then Swiss population data should be used [3]. The laboratory can use a 0.01 sub-population correction factor for the statistical calculations. Different mutation models can be considered.

Recommendation #12. The preparedness plan of the laboratory needs to include policies for family notification, long-term sample disposition, and data archiving.

Remarks:
No further remarks. Family notification is not under the responsibility of the DNA laboratory.

References
[1] M. Prinz, A. Carracedo, W.R. Mayr, N. Morling, T.J. Parsons, A. Sajantila, R. Scheithauer, H. Schmitter, P.M. Schneider. DNA Commission of the International Society for Forensic Genetics (ISFG): Recommendations regarding the role of forensic genetics for disaster victim identification (DVI). *Forensic Science International: Genetics 1* (2007) 3–12.
[2] M.D. Coble, J. Buckleton, J.M. Butler, T. Egeland, R. Fimmers, P. Gill, L. Gusmão, B. Guttman, M. Krawczak, N. Morling, W. Parson, N. Pinto, P.M. Schneider, S.T. Sherry, S. Willuweit, M. Prinz. DNA Commission of the International Society for Forensic Genetics: Recommendations on the validation of software programs performing biostatistical calculations for forensic genetics applications. *Forensic Science International: Genetics Volume 25* (2016) 191-197.
[3] M. Zieger, S. Utz. A "forensic biobank" to establish comprehensive genetic frequency data for Switzerland. *Forensic Science International: Genetics 40* (2019) 46-51.

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