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Challenges in the identification of dead migrants in the Mediterranean: The case study of the Lampedusa shipwreck of October 3rd 2013

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ABSTRACT

Every year thousands of migrants die during the endeavour t\o reach the Italian coasts, making the Mediterranean the theatre of one of the greatest tragedies of mankind. Over 60% of these victims is buried unidentified: one of the reasons behind this is related to the specific difficulties and lack of strategies concerning AM and PM data collection. The present article describes how Italy is trying to face the problem of migrant identification, thanks to the collaboration between government, the Italian national police and universities. In particular, this is the first pilot study carried out to identify the victims of the second greatest tragedy of its kind off the Italian coast, near Lampedusa, on October 3rd 2013, which caused 366 victims. The present article shows the strategies conceived to collect postmortem and especially antemortem data and to compare them to identify matches, using medicolegal, anthropological, odontological and genetic approaches. Thirty-one victims out of 53 missing sought by relatives were identified (58.5%). The type and the quality of antemortem data available, generally photos and videos, pinpoints the importance of the face and the body for identification when the bodies are well preserved and how DNA analyses may at times present difficulties. In fact, critical points emerged concerning especially the lack of genetic information of the populations to which the victims belonged, the number of genetic markers needed to reach a statistical support for the identification and the need to adopt lineage markers such as mitochondrial DNA and Y-chromosome polymorphisms to identify parental relationships. This pilot study however has proven that families continue to seek their relatives and that it is possible, as well as mandatory, to identify migrant victims in spite of the difficulties in the collection of antemortem and postmortem data. In addition, considering the peculiar scenario, novel strategies for positive identification have to be defined in each field (anthropological, odontological and genetic) as well as in combination.

1. Introduction

The phenomenon of migration from the African and Middle-eastern Countries to the European ones has increased exponentially in the past five years, representing one of the more serious situations within the current migration crisis. As regards the EU scenario, among the many routes embraced by migrants or refugees in their journey, the Central Mediterranean Sea route is frequently the chosen one resulting in dangerous crossings where thousands of victims die.

The precise number of deaths occurring globally is not yet well documented, but according to what has been reported by the International Organization for Migration (IOM), who has tried to track and estimate the worldwide fatalities occurring during the

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transnational migration flows, the Mediterranean sea is the area where in the last three years most of the migrant deaths occurred: out of the total worldwide migrant deaths 62,3% (3279), 65,9% (3777) and 75,7% (3972) respectively for 2014, 2015, and 2016 occurred in the Mediterranean [1–3]. It is likely that these numbers are underestimated. The emergency represents a continuous flow of deaths: some in accidents with tens of victims, others with hundreds.

In this dramatic situation it is also important to point out another serious implication related to this death scene, which is the low yield (and interest in) identification of the victims. In general, the identification of the dead is of paramount importance, and it is universally recognized that human beings have the right not to lose their identity after death for legal, religious, cultural and other reasons [4,5]; families have the right to know the fate of missing relatives for several reasons which go from the right to resolve ambiguous loss, to the administrative rights of those who remain behind, such as widows and orphans [6]. Moreover, there are many juridical, legal, administrative and civil repercussions on surviving relatives which may not be immediately apparent: countries such as Sudan and Eritrea request, for example, death certificates of the parents in order to reconcile orphans who are still minors with other living relatives in Europe.

If on the one hand, the identification of bodies in response to domestic large-scale deaths as well as to international mass disasters (e.g. air-crashes, natural disasters etc.) is seen as an imperative and quasi-automatic national and international action by States, on the other hand there is a completely different handling of the matter in the case of dead migrants. There is still an absence of national and international actions that should be taken in order to facilitate the identification of the many migrant/refugee victims once their bodies resurface and/or are recovered from the Mediterranean Sea. Indeed, many of the victims are unidentified and it is likely they will remain nameless if no adequate forensic strategies will aid the identification process.

At the moment, existing authorities are incapable of dealing with the problem, not only because of the large number of bodies but especially because of the lack of the appropriate strategies for data collection required to deal with this scenario, which is unique. In general, in mass disasters ante mortem and post mortem data are collected and then compared in order to verify possible ante mortem and post mortem matches. Once matches are found different methods can be applied to reach positive identification: DNA, fingerprints, odontology, etc. Even extremely challenging cases, such as the 2004 Tsunami, an event involving thousands of victims, have been tackled in this fashion [7]. In the case of dead migrants, and in particular for the Mediterranean, the problem however is much more complex and presents in fact new dilemmas: organizational, administrative and scientific. First of all such victims may be related to a large disaster, with hundreds of bodies, but also to smaller incidents, spread across the years and across the Mediterranean. Furthermore there is no official data on who could have been on the boats (if the bodies are related to a shipwreck) or, for single bodies appearing on the shore, not even an idea of who they could be. Therefore we are facing hundreds and thousands of bodies collected over the years in different areas and in different countries. At times, for a same shipwreck, bodies end up in different countries. Furthermore for some of these victims autopsies may be requested, or only external examinations, depending on the prosecutors' orientation, and may be performed by the Police, by Universities or by private pathologists. Thus the data from different disasters, large or small, may be extremely dishomogenoeus, incomplete, "held captive" in the prosecutors' offices through the south of Italy and never pooled into a unique dataset. Therefore coordination of information and gathering of postmortem data is much more difficult. Even greater difficulties concern the collection of antemortem data. This kind of data is usually presented by relatives looking for their missing, and consists mainly in personal belongings of the missing for DNA extraction and analysis (e.g. toothbrushes), fingerprints, clinical information (e.g. surgery) or dental data. In the case of the Mediterranean tragedy this kind of data is rarely available. People claiming their dead are usually half siblings or cousins or other distant relatives and friends who have fled their countries of origin previously and have heard "on the grapevine" or from survivors that their relative was "on that boat". It is unthinkable to recover personal belongings for DNA analysis from the families in the country of origin as this in many cases would put them in danger because of the specific political scenario, or because no contact can be made at all in the country of origin. Furthermore the relatives or those claiming missing persons are spread out all over the world, particularly in Europe. Thus the kind of data recovered for identification in these situations will generally consist of photographs, descriptions, videos, but very rarely of clinical data. In addition identification by DNA will not always be possible for many since the degree of genetic affinity of those claiming the dead will not be appropriate. Thus new identification strategies need to be devised, since facial traits, for example, may be the only piece of AM data [8,9].

Furthermore, Italy and other southern European countries are swamped by the arrival of the living (only in the first 10 months of 2017 over 90,000 living have arrived on Italian shores), and having to take care of the tens of thousands of living migrants every year. Thus from a point of view of financial and personnel resources, it is impossible to deal with this problem in a standard fashion [6]. The present article wishes to show how in this quasi-desperate scenario Italy is trying to tackle the problem of identifying dead migrants [10,11] by joining forces also with the university forensic community. This has been possible through the office of the Commissario Straordinario per le Persone Scomparse, an office which was created in 2007 initially to solve domestic problems of unidentified bodies.

The purpose of this report is to present results from the first pilot study performed to identify the victims of the disaster which occurred off the coasts of Lampedusa on October 3rd 2013. This, which was the second largest mass disaster of its kind in Italy, represented a situation where over 366 bodies had been treated in the same manner from a forensic point of view. Therefore at least similar PM data existed for all bodies and was available (though no antemortem data collection had ever been commenced given the above mentioned difficulties). This study hence represents the strategies devised for the collection of postmortem and antemortem data concerning this disaster and issues regarding identification.

2. Material and methods

2.1. The Lampedusa October 3rd 2013 shipwreck

On October 1st 2013 a 20 m long fishing boat with at least 500 estimated migrants packed on board (mostly Eritreans, Ethiopians and Somalis) set out from the port of Misrata in Lybia with the intent to reach the Italian coasts. Two days later, the boat sank no more than one kilometre off the shores of Lampedusa after a fire broke out, thus triggering a general panic that led to its capsizing. Among the migrants, only 155 survived and were rescued, while the rest drowned. The scale of the disaster was defined the following days: 366 dead were recovered, to which an unknown number of victims still missing and never retrieved has to be added (Fortress Europe 2016).

This was the first major migrant disaster off the Italian coasts which obtained a standardised post-mortem treatment with respect to the other smaller disasters. The recovery operations of the victims performed by the Italian law enforcement agencies and the Italian Navy started very shortly after the tragedy. No autopsies were requested by the Prosecutor, but an external examination of the bodies was carried out by the Italian DVI team (Disaster Victim Identification team) of the Polizia Scientifica. During the external examination of the corpses and before burying the bodies, samples for DNA analysis were collected and subsequently analysed at the Forensic Genetic Lab of the Scientific Police Service of Palermo (Italy).

All postmortem data collected was then acquired by the Italian Government's Office of the Commissioner for Missing Persons (UCPS-Ufficio Commissario Straordinario per le Persone Scomparse), which, since its foundation in 2007, coordinates the recovery and the identification of missing persons and unidentified cadavers (usually domestic) in Italy. This was the first step in making the Commissioner's Office the focal point for the collection of antemortem and postmortem data concerning dead migrants also.

2.2. Set up for AM and PM data collection

As previously mentioned this was the first major disaster off the Italian coasts which obtained adequate attention with respect to the other smaller disasters: in fact although autopsies were not requested by the Prosecutor's Office, for each body an external examination was performed by the Polizia Scientifica immediately before burial of the bodies and samples were taken for DNA analysis. A set up for antemortem data collection however had never been envisaged (for this or any other disaster of its kind), but at least post mortem data had been collected uniformly for all 366 victims. This meant that the disaster could be used as a pilot study to verify whether it was possible to collect antemortem information to compare with the post mortem data, and thus identify the victims; this also, however, meant getting in touch with the families—the most difficult step, given that they could be dispersed in the countries of origin, in countries of transition or in countries of destination.

For this purpose the Office of the Commissioner for Missing Persons of the Italian Government, after a series of consultations, on September 30th, 2014 signed an MOU with the Department for Civil Liberty and Immigration and the University of Milano (due to its previous collaboration with LABANOF, since 2007), aimed at promoting actions for the identification of the victims who died in the disaster of October 3rd by trying to create a data set of the post mortem (PM) information from the victims and of the ante mortem (AM) data provided by relatives of the missing suspected to be on board [12]. LABANOF and UCPS designated the Forensic Genetics Lab of the University of Pavia as its DNA counterpart in this project, which would become the DNA component of the identification team for the analysis of antemortem DNA samples. The Pavia Lab then included in the team a forensic statistician from the University of Pisa in order to define the DNA parental relationshis between PM and AM.

All was organized and later performed in accordance with the Prosecutors' Offices and according to national data protection regulations.

2.3. PM data collection

2.3.1. Medicolegal and anthropological data

The medico legal external examination which had been performed immediately after the disaster by the Polizia Scientifica resulted in identification forms containing a concise description of sex, age, height, personal descriptors, clothing and personal belongings, along with a photographic documentation of bodies, faces, personal descriptors, clothes and personal items. All data was collected by the UCPS Office one year later in the form of pdf files and then transmitted to Labanof. Here a dataset (sex, apparent age, personal descriptors, etc.) and a photographic archive containing photos of faces (most victims were well preserved), body personal descriptors (tattoos, scars, etc.), clothes and personal effects of all the victims was created. To each victim the same number given upon recovery, from 1 to 366, was attributed. Such a dataset and photographic archive were essential for making the post mortem information easily accessible not only for the scientists but also for the relatives, a frequently useful starting point towards a possible match. The dataset was initially a simple excel document which allowed quick access to the data and screening by sex, age, tattoos, scars, personal belongings such as rings, bracelets or necklaces for example; it was to be further transferred to the ICRC AM PM system and software. The photographic data was organized according to the numerical progression given to the bodies (from no. 1 to no. 366) on a PowerPoint presentation (which was also fully printed) representing one by one the details both physical and related to personal belongings and clothes, to be viewed by willing relatives. These images were also to be used by the forensic scientists for photographic comparison and superimposition with antemortem images.

2.3.2. DNA analysis of the victims' sample

Many victims were recovered immediately after the shipwreck, and saliva or blood (111 and 154 respectively) were sampled by the Polizia Scientifica for DNA analysis. Other bodies were later recovered in an advanced state of decomposition and for this reason a muscle sample was collected (99 bodies). DNA profiling was carried out by the Forensic Genetics Lab (ISO/IEC 17025) of the Scientific Police Service of Palermo, Italy, using the ESX commercial kit (16 STR loci plus amelogenin). DNA extraction was carried out using the EZ1Advanced XL Biorobot with the DNA Investigator kit (Qiagen), following the manufacturers' instructions. 2 μl aliquots of the extracted DNA were quantified in the Applied Biosystem 7500 Real-Time PCR using the Quantifiler Duo DNA Quantitation kit and analysed with the HID Real Time PCR Analysis Software v. 1.1 (Thermo Fisher Scientific). For DNA amplification, NGM SElect (Thermo Fisher Scientific) and PowerPlex ESX 17 Fast System (Promega Corporation) were used with a 0.3–0.5 ng input DNA amount. The maximum input DNA volume was employed for those samples which gave a total DNA amount below 0.3 ng. The amplification products were separated through capillary electrophoresis on the ABIPRISM 3500 Genetic Analyzer (Thermo Fisher Scientific), using the Data Collection software version 1.0. Allele call was performed with the Gene Mapper ID-X software version 1.3 (Thermo Fisher Scientific).

This data was transferred to the UCPS Office then through Labanof to the Forensic Genetics Laboratory in Pavia.

2.4. AM data collection

Many were (and are) the problems concerning the collection of proper AM data in this peculiar humanitarian context: the impossibility to get in touch with the missing persons' relatives because of the political situation characterizing some of the countries of origin (which could compromise their safety), the unawareness of the families regarding the possible fate of their loved ones or even the fact that someone is trying to identify the victims, the lack of evident services where to ask for information or seek for the missing, and again the worldwide scattering of relatives. In order to facilitate the gathering of AM data, representative international humanitarian organizations as IOM (International Organization for Migration), CRI (Italian Red Cross), ICRC, Amnesty International, Fondazione Migrantes and other associations such as “Borderline-Europe” and “Comitato 3 Ottobre”, as well as Embassies, were involved by the Office of the Commissioner for Missing Persons (UCPS) in order to inform the living relatives, particularly across Europe, that antemortem data collection for this tragedy was commencing; the communities of Eritreans, Ethiopian and Somalis particularly across Europe were encouraged to report the disappearance of their loved ones by coming to interviews for antemortem data collection to be held at set dates in Italy, at first in Rome (2 meetings) and then in Milan (9 meetings). At each interview a team consisting of many different experts was present: a representative of the Ministry of Interiors and of the Commissioner’s Office, a trained psychologist, a forensic anthropologist/odontologist, a forensic pathologist and a cultural/linguistic mediator who cooperated closely in order to cover all the areas involved in the process (legal, forensic, psychological and cultural support). The relatives came from Germany, Switzerland, Italy, Norway, UK, Denmark, France.

The ICRC “Missing Person Form” [13] was used in this instance for data collection. During the interview all material including photos, videos, even from social networks, such as Facebook, was collected as well as, in rare instances, medical certificates describing surgery or pathology. Also the PM photographic archive was consulted by relatives whenever they agreed and felt comfortable to look at it; it proved to be remarkably useful in many cases for at least an initial recognition of faces or of personal items (to be subsequently identified through scientific methods).

Finally, the interview process ended with the sampling of biological material (saliva) in case of a close relative or next of kin (preferably parents, siblings, sons). All was performed with informed consent (signed). For each relative 3 buccal swabs were taken and stored at −20 °C. In some instances relatives or friends would bring fingernail clippings, saliva, toothbrushes or hair from closer relatives who could not come to the meeting. The DNA material was then submitted to the Laboratory of Forensic DNA of the University of Pavia where it was processed for the genetic analysis.

All AM files were attributed a file number (AM x); the same number would be given to all material (photographs, swabs) related to that missing person.

These calls and interviews are still ongoing and currently the AM files and forms of 53 missing in the disaster of October 3rd 2013 have been opened (9 with information from non genetically related individuals (friends, spouses); 11 from second degree relatives other than half siblings; 24 from full siblings and 2 from half siblings; 7 from parent child relationships). In certain cases for one victim more relatives were present.

For these same AM files, as concerns non genetic material, photographs of the body or face were provided for 50 missing (through printed photographs, CDs, videos, Facebook), but only 26 were of sufficient quality to be used for photographic comparison with post mortem images. AM data from relatives of victims of other disasters was and is also being collected, including that from the families of 18 Syrians feared dead from the disaster of October 11th 2013, not discussed in this article.

2.4.1. DNA analysis of antemortem data

Buccal swabs were directly obtained from 35 individuals, whereas another 17 provided hair, nails or saliva. Genetic typing was carried out by the Laboratory of Forensic DNA of the University of Pavia. DNA from buccal swabs and saliva was purified by 5% Chelex extraction [14], or by the QIAamp DNA Mini kit extraction (Qiagen). DNA from hair samples was extracted by the DNA IQ System Tissue and Hair Extraction kit (Promega), following manufacturer’s instructions. For DNA amplification, the PowerPlex ESX 17 Fast System kit (Promega Corporation) was used. Amplification products were separated by capillary electrophoresis using an ABI PRISM 310 Genetic Analyzer (Applied Biosystems); allele call was obtained by GeneMapper ID version 3.2.1 software (Thermo Fisher Scientific).

2.5. AM PM comparison

2.5.1. Medicolegal and anthropological search for matches

AM–PM associations (in other words possible matches) arose as a result of varying procedures. In some instances the relatives would arrive with a suspicion that their loved one corresponded to a specific body with a given number; this was usually through word of mouth from those who had survived the disaster; other times the relatives during the interview would give information on personal descriptors which would immediately be sought in the database. If an initial correspondence was found, the images of the corresponding postmortem file would be shown to the relative (if the relative was willing) in order to verify possible recognition. Sometimes the associations were made by the relatives who would search through the photographic archive; in other instances possible matches were performed by the forensic scientists later in the lab when comparing AM data, faces and personal descriptors to the single PM files, for example by evaluating morphological features on the faces by means of specific atlases that classify facial traits (such as the Dusseldorf–Milano–Vilnius atlas) [15,16]. Finally, associations could be made purely through DNA comparisons of AM and PM assets (by AM genetic asset we intend the DNA referring to an AM form which comes from a relative), as described below.

2.5.2. DNA data analysis

The genetic composition of the victim sample was analyzed by the exact test of Hardy–Weinberg equilibrium using ARLEQUIN 3 [17], and for population sub-structuring using STRUCTURE [18]; in addition, the Wright’s fixation index F was calculated for each locus. As no significant population stratification was detected in any test, the allele frequencies to be used in kinship testing were estimated from the victim database.

The genetic profiles of all putative relatives and all victims were paired to each other. The distribution of the number of loci with 0, 1 and 2 shared alleles was determined [19], and the likelihood ratio (LR) of parent–child (PC) and full siblings (FS) vs. non-relatives (NR) was computed for each pair by the DVI (Disaster Victim Identification) module of FAMILIAS 3 [20]. The null distributions (i.e., of unrelated individuals) of allele sharing and LRs was obtained by randomly permuting the alleles of the victim database; five such random sets were obtained, and pairwise LR calculations were repeated for each. This allowed estimating the probability that a pair of unrelated subjects, formed by any putative relative and a victim, exceeded a given LR value. As the chance of finding LR values $>10^{3.5}$ for both PC/NR and FS/NR was virtually zero, a LR $>10^4$ was chosen as a conservative threshold for identifying first-degree relationship. Assuming a prior probability = 1/N (N being the number of victims), this corresponds to a posterior probability >95% [21]. In parallel, the blind search option of the DVI module of the program Familias 3 was used to calculate for all victim profiles pairwise likelihood ratio of selected familiar relationships (parent-child, full siblings and half siblings).

2.5.3. Classification of AM–PM comparison

Six categories were created to describe the status of a missing person:

1) Identified: a full correspondence between genetic, anthropological, odontological and/or medico-legal data, either in combination or alone, of the missing person and victim

(fingerprint analysis was not possible although most victims were well preserved because of the lack of AM fingerprints in most cases).

Identification was to be possible only via:

- Non clinical odontology. The PM dental profile is compared to AM photographic material that depicts the missing person smiling or with his/her mouth open [22,23]. Identification is achieved if enough elements are available by superimposing and/or comparing same morphological features visible on both AM and PM images, such as shape, profile, color, misalignment and malposition of teeth [24]. Usually in this evaluation the anterior dentition is used because it is the portion that is more clearly visible in AM photos. If the AM and PM photographs have the same orientation, it is possible to overlap the two images to carry out a 2D–2D superimposition according to literature [25,26].
- Anthropology of body features and marks. On well preserved cadavers this method can identify the presence and position of tattoos, scars, piercing and moles on the face and body [27]. Corresponding information on the presence of tattoos for example is not sufficient for identification [28]. However, when an AM photo depicting the feature is available, and comparison or superimposition with the PM photo is possible or, even, a 2D–2D superimposition of the two photos in the same orientation, then this can be, when combined with the general biological profile, a valid method of identification, always according to literature [27,28].
- DNA: in cases where the value of the LR associated to the found match of first degree relationships was equal to or greater than 10^4.

1) Biological match: good or strong correspondence between AM and PM biological data, that however is not enough to produce a judgment of identification.
2) Personal belongings match: good correspondence between AM and PM non biological data, which however is not enough to produce a judgment of identification and needs the acquisition of further anthropological or odontological data or DNA exam.
3) No match: a possible match for the AM file has not been found among the victims; further AM data may be necessary.
4) Recognition: relatives or acquaintances recognized the cadaver's face on the photos. This however does not imply certain identification.
5) Erroneous recognition: comparison of the AM file with the suspected visually recognized PM has been proven wrong through biological analyses.

3. Results

Before illustrating the results, it is important to recall that of all non genetic PM data available, only 50% had clear photographs of the face with a frontal and lateral view, and with visible tattoos, scars, moles or facial traits; in the remaining 50% the examination of personal descriptors was severely hindered by decomposition.

Of all AM photographic material examined (50 photographs), 26 photographs were of sufficient resolution for the analysis of anthropological traits: of these 21 depicted clear and usable images of tattoos, dental profiles, moles, facial traits, and were useful for identification or matches.

As concerns DNA, PCR amplification of the DNA recovered from the victims provided 346 full genetic profiles for 16 autosomal loci plus amelogenin and 17 partial profiles, missing from one (n = 9) to six loci (n = 8). In a single case, no profile could be achieved. The final victim database composed by 363 genetic profiles was uploaded in the *Familias 3* software setting up of the DVI module, to identify potential familiar relationships using the "*blind search*" option. The allele frequencies estimated from the database were used, according to the statistical analyses which pointed out no evidence of departure from population homogeneity in any test. According to criteria already described, first degree relationships with LR values $\geq 10^4$ were considered ascertained. The blind search revealed the presence of four familiar groups among the victims composed of three mothers with their corresponding children, a father-mother duo with the corresponding child and five parent–child relationships, each relationship showing LR values greater than 10^4.

Fifty-two samples corresponding to relatives of missing persons were acquired, starting from different biological samples such as saliva, nails and hair. These samples were submitted to DNA extraction and PCR amplification generating 43 full genetic profiles. No reliable DNA profiles were obtained from nine of them due to the poor quality of the biological substrate (hair or degraded saliva).

The genetic comparison of the two genetic databases of reference persons and victims searching for first-degree relationships (parent/child and full siblings) led to the genetic identification of 23 victims, in some instances being members of multi-person pedigrees.

Specifically, 6 parent–child and 17 full siblings relationships were genetically highlighted between the victims and the relatives, with LR values between 10^5 and 10^9 and 10^4 and 10^{13}, respectively. Search for missing relatives was instead unsuccessful or unresolved by current data analysis in 12 cases (all from different families); for some of them, results from additional genetic typing is at the moment pending.

Hence, results of the comparison of all biological data (medico legal, anthropological, genetic, odontological) led to the following, summarised below per classification status.

Identification: 31 victims/missing were certainly identified according to the following methods.

- **Facial/anthropological/odontological methods (non genetic biological methods) only**

8 missing for which no genetic data was available were identified through non genetic methods, as illustrated in Fig. 1.

- **Genetic analyses only**

9 individuals were identified only through DNA. For these individuals no other AM information was available except DNA.

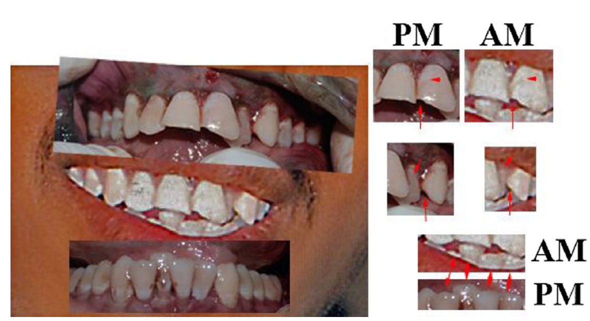

Fig. 1. The figure shows an example of the comparison of specific dental traits visible on the AM and PM photographs of the missing person and of the victims (on the left, upper and lower images are upper and lower arch PM, the middle is AM). The correspondence of some peculiar characters at least for 8 teeth is shown on the right.

However these data were considered sufficient alone to reach a conclusion of identity.

- **Non genetic methods and DNA**

In 14 cases both anthropology and DNA led to identification.

- In 8 cases both anthropology or genetics per se would have been sufficient for identification;
- In the remaining 6 cases anthropology supported a match which was confirmed by LR values $\geq 10^4$ of the genetic analysis.

Possible matches: eleven possible matches have been identified but to this moment information is insufficient for certain identification. One example of such possible matches which cannot yet however be considered identified is represented by a case where for one of the family groups identified among the victims (one mother and two children) DNA analysis provided when compared to the woman's full brother a LR of 6.81×10^3, very close to the selected threshold for identification (10×4) but insufficient to fully identify with DNA only. Furthermore the brother recognized his sister on the PM photograph and told us that she had a cross tattooed on her forehead: the body identified as the probable match indeed has a cross on the forehead, however no AM pictures of her are available in order to carry out superimposition of the tattoo. This case is still under examination and we are searching for more genetic and photographic data from other relatives. Moreover, additional genetic typing of autosomal and mtDNA markers have been planned in order to increase the LR value. The same approach will be used for the nine samples for which the LR value was above 10×2 and below 10×4.

No match: 11 AM files still have no possible matches at all.

Erroneous recognition: in 2 cases out of the 53 for which the AM data were available, odontological and DNA data confirmed independently that at least two recognitions (i.e. visual recognitions performed by friends or relatives on photographs soon after the disaster) were incorrect.

4. Discussion

The present pilot study on the Lampedusa disaster although allowing for the identification of only 31 individuals, has proven several important points.

First of all it has shown that even in a worse case scenario, families will continue to look for their loved ones, and go to extreme measures to identify them. In the present case, antemortem data collection was (and is) perhaps the most challenging issue. Relatives are currently still unaware of the activities that are being perpetrated in order to identify these victims in Italy and the means through which the families of 53 victims who showed up at the interviews had been reached are to be considered minimal and haphazard (through word of mouth, embassies in Europe, through the grapevine and more or less organized communications of NGOs). Finally, for Eritrea in particular relatives could not be contacted through their governments in their own countries because of the risk of retaliation on families of those who have escaped the country. Regardless, the families of over 50 missing came at their own expenses from 7 different European countries to Italy to bring AM data. One can only imagine how much more efficient a more thorough and diffuse AM collection system could be in recruiting relatives and collecting AM data.

This experiment also proved the technical challenges one is faced with for identification. Contrary to "normal" disasters, the quality of ante mortem data is very different: AM data belonging to the missing person (for example toothbrushes) are impossible to come by. The victims in fact left their countries of origin and homes months or years before their disappearance; and frequently the relatives that come looking for them are siblings, at times half siblings. This leads to difficulties with respect to the genetic analyses, as will be commented later on.

At times no DNA analyses could be performed for lack of "appropriate" relatives. In this case normally other "primary identifiers" would come in, such as antemortem clinical data or fingerprints. In the case of this disaster, though cadavers were mostly well preserved, antemortem fingerprints were not available from Eritrea or Ethiopia, nor was dental clinical data (or other clinical radiological data) available for any of the missing. Moreover, some AM information was difficult to collect due to the poor living conditions, for example AM documentation about health conditions (illness, fractures, surgery).

What was frequently available were photographs and videos (from parties, weddings, common life scenarios). Many of the interviewed relatives or friends came from countries different from their original country (for example, until now, Switzerland, England, Sweden, Germany, Norway, Holland and Belgium) and they had not seen the missing person for years. In many cases, the only contact that they had with the missing person was through Facebook: this way it was possible to obtain recent photos of the missing person.

Therefore, the face, but also the body, with its varied information coming from physiognomy and simple facial and ear traits, to dental profiles visible when smiling, tattoos and scars, were able to give a multitude of information. Although all these are powerful identification elements, it is also true that they will lead to morphological identification which is not quantifiable in the expression of its probabilities as genetic identification. Regardless, it is accepted in literature that one can identify with significant peculiarities – be they dental traits or a tattoo. Nonetheless this brings on the need for these personal descriptors to be adequately represented in the post mortem images. For example, with regards to the face, where the shape of the mouth and nose and patterns of moles, for example, can be superimposed for identification [29] the AM face and PM face have to be in the same orientation. What may unfortunately happen is that the post mortem face has been photographed in a standard position (e.g. frontal and lateral) whereas the AM picture which will arrive later (months or years) will show a face in a different position. This makes the comparison impossible or more difficult and less reliable. In order to overcome this, new protocols have to be developed and implemented at autopsy or external examination of unidentified decedents, in other words the face has to be acquired in 3D. This will allow for a 3D model of the face of the victims to be oriented in any manner for a future comparison or superimposition with the antemortem image.

This study also confirmed the huge risks of visual recognition. In most countries, including Italy, visual recognition is the main manner of attesting the identity of a cadaver by a relative, who assumes the formal responsibility of recognizing the corpse through a visual examination. Interpol and recent literature warn against the risks in this procedure when it is used as unique identification method especially in mass disasters [30] because it is based on the subjective perception of a person and it is not founded on scientific elements. Until now, however, recognition has often been utilized in mass disasters as a faster ID method. After the Bali attack of October 12th 2002, 18 subjects were identified through visual recognition by family members and, among these, 8 were found to be incorrect [31,32]. Also for the victims of the Tsunami in Thailand on 26 December, 2006, despite the previous experience of erroneous identifications and recommendations provided by Interpol, this procedure was used. In this circumstance, 32.3% of identifications were made with visual recognition (even with decomposed bodies) and this led to the exhumation and re-examination of several bodies already buried in mass graves [33].

In our case, this situation was made worse by the fact that relatives had not seen the missing person for several years. In our study two erroneous recognitions were detected.

Postmortem data in the case of the Lampedusa disaster was partial also because full autopsies had not been requested and therefore the quality of PM data dropped, especially given the lack of dental and bone samples for example for aging. This had repercussions on the possibility of creating precise biological profiles (sex, age and ethnicity) and on the possibility to identify victims through anthropological and odontological methods.

Genetic analyses also presented some setbacks.

DNA profiling applied to disaster victim identification (DVI) has been adopted since the mid-1990s to provide an identity to victims of war conflicts such as the ones buried in mass graves in the Balkans [34]. The same approach was then adopted to other mass fatality or natural disasters such as the victims identification of the World Trade Center attack in 2001 [35] and the Tsunami in Thailand, in 2004 [36].

The gold standard of the genetic identification of any recovered corpse is the comparison of its genetic profile (post mortem) with the DNA extracted from ante mortem material from candidate persons. The difficulty of collecting such material among the putative relatives has been already discussed before. Therefore, genetic identification must be conducted mainly by kinship analysis. This was indeed the case in the present work.

Migrants are often heterogeneous groups coming from several Sub-Saharan African countries, spanning from West (Ivory Coast, Guinea) to East Africa (Eritrea, Somalia). This may represent a difficulty in kinship analysis, as exact computation of likelihood ratios requires reliable estimates of allele frequencies, for which there may be no adequate data. In the present work, this was a minor problem, as most people on the boat were from Eritrea, Ethiopia and Somalia and no significant population stratification was evidenced in the victim sample by genetic tests. This allowed us to obtain the STR allele frequencies to be used in kinship testing directly from the victim database.

Blind search of possible relatives of all reference persons in the victim database raises the problem of the inflation of false positives due to multiple comparisons. We restricted the analysis to the first-degree only (the vast majority of the missing relatives), and obtained the corresponding null distributions for both allele sharing and LR by repeatedly permuting the alleles of the victim database; this allowed us to easily spot the parent child pairs (nine identified out of ten claimed), and to set up a conservative cut-off LR value (10^4) to accept full sibling relationships (19 established out of 32 claimed, some involving the same victim). For nine putative FS pairs, the LRs ranged from 10^2 to 10^4; in such cases, we scheduled the typing of additional STR marker or lineage markers, such as Y-STRs or mtDNA. At any rate, it is possible that some victims could not be genetically identified because the claimed real-life relationship does not correspond to the genetic relatedness; of course, in such circumstances it is unethical to investigate the details, and the genetic data may be substituted by other primary identifiers.

5. Conclusions

The tragedy of dead migrants in the Mediterranean represents a true challenge for those who have to identify the victims, not only because of the dispersion of PM data but especially because of the difficulty in reaching out, for AM data collection, to relatives who may be in the countries of origin, in transition or in countries of destination

These types of mass disasters also challenge the general standards for identification because the primary ID methods become less useful and inappropriate (for the difficulty of taking DNA sample from close relatives or for the absence of fingerprints or dental and health records), while the so called "secondary ones" become more relevant. Thus, it is necessary to modify the criteria of collecting both PM and AM data. Faces for example are becoming more and more important and one should begin to think of reporting their traits in an appropriate manner (one example through 3D scanners which are nowadays extremely cheap).

In the case of the Lampedusa disaster of 53 reported missing by their relatives 31 were identified, therefore almost 60% (58.5). This fact per se tells a long story: that people are still looking for their loved ones, and that it is possible though more difficult to collect AM and PM data.

Of course, novel strategies of identification have to be sought, both anthropological, odontological and genetic – or, better yet, combined strategies. This however cannot be used as an excuse to decline the challenge of giving these victims back their name and removing the relatives from the grips of ambiguous loss.

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