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Percentage of Body Recovered and Its Effect on Identification Rates and Cause and Manner of Death Determination*

ABSTRACT: Anthropologists frequently encounter cases in which only partial human remains are recovered. This study reports how the percentage of the body recovered affects identification (ID) rates and cause and manner of death determination. A total of 773 cases involving anthropology consults were drawn from the New Mexico medical examiner's office (1974–2006). Results indicate a significant correlation between body percent recovered and ID rates, which ranged from 89% for complete bodies to 56% when less than half the body was present. Similar patterns were evident in cause/manner determination, which were the highest (83% and 79%, respectively) in complete bodies but declined to 40% when less than half the body was found. The absence of a skull also negatively impacted ID and ruling rates. Findings are compared with general autopsy ID rates (94–96%) and cause/manner determination rates (96–99%) as well as prior published rates for individual casework and mass death events.

KEYWORDS: forensic science, forensic anthropology, personal identification, cause of death, manner of death

In cases involving decomposed or skeletal human remains, anthropologists often recover incomplete bodies. Intuitively, investigators would predict that the greater the percentage of a decedent's body recovered, the higher the probability that the individual will be positively identified or that the cause and manner of death can be determined. Certain anatomic regions are more likely to be represented in antemortem records and any one skeletal element may hold evidence of the cause or manner of death or identity (1).

Previous studies have noted that partial human remains (particularly those separated by time or distance) can confound identification (ID) attempts (1,2) and that anthropology consult cases have a tendency to over-represent those who die violently (3). However, no prior reports have quantified the effect of incomplete body recovery on ID rates. Although the incidence of trauma in recovered skeletal remains has been discussed previously (3–5), this study also reports rates of cause and manner determination for decomposed remains.

Materials and Methods

A total of 773 cases involving decomposed and skeletal remains analyzed by forensic anthropologists at the New Mexico Office of the Medical Investigator (OMI) from 1974 to 2006 were included in this study. Information was drawn from completed case files, which included anthropology and autopsy reports, summary of findings, reports of death, and scene information. All individuals were unidentified at the time of the anthropological examination.

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The percentage of remains recovered was scored as: complete; 76–99% present; 51–76% present; 26–50% present, <25% present; or represented by a single skeletal element or cranium only. Percentages were determined following Grisbaum and Ubelaker (4), which weighted larger elements more heavily than smaller bones, rather than calculated as the number of bones present out of 206. The presence or absence of the skull (partial or complete) was noted. The final cause and manner ruling, whether trauma was observed at autopsy, and ID status of each case were also recorded. All information was compiled in a Microsoft Excel database and analyzed using SAS 8.0. Categorical variables were analyzed using χ^2 tests. Statistical significance was set at $p < 0.05$.

Results

Descriptive statistics for the overall sample ($n = 773$) are provided in Table 1. A breakdown of the percentage of remains recovered is illustrated in Fig. 1. The effect of body percent recovered on positive ID rates, cause of death determination, and manner of death determination is shown in Table 2.

Discussion

Overall ID rates in this study are significantly higher than those reported previously for similar cases. Positive ID of skeletal remains cases has been cited to be as high as 50% (5,6) and as low as 25–30% (6,7). Bass and Driscoll (8) reported ID rates of 30% for skeletal remains recovered in Tennessee from 1971 to 1981. Grisbaum and Ubelaker (4) collected data regarding ID rates for skeletal remains cases analyzed by the FBI but found a lack of follow-up information regarding the final resolution of cases, which prevented any meaningful conclusions. In this study, the anthropological examinations were conducted at autopsy. In addition, the first author (D.A.K.) is responsible for establishing identity and has unrestricted access to all aspects of each death investigation.

ID rates in mass death scenarios also vary from those reported here. Recovery efforts at the World Trade Center following the

TABLE 1—Descriptive statistics from anthropology consult cases: 1974–2006.

Total Number of Cases	773
Positively identified	597 (77%)
Not identified	176 (23%)
Trauma evident	533 (69%)
No evidence of trauma	220 (31%)
Skull recovered	659 (85%)
Cause of death determined	506 (66%)
COD unknown	267 (34%)
Manner of death determined	482 (62%)
Homicide	211 (27%)
Accident	206 (27%)
Suicide	42 (5%)
Natural	23 (3%)
MOD undetermined	291 (38%)

MOD, manner of death.

September 11, 2001, terrorist attacks had resulted in the ID of 1565 of the 2749 (57%) known missing persons as of 2005 (9). Boles et al. (10) report that 75% of individuals exhumed from two Guatemalan mass graves were identified. Positive ID was established for 82 of the 88 victims (93%) of the Branch Davidian compound fire in Waco, TX, in 1993 (11).

As a final note regarding ID, it is relevant that the introduction of DNA testing of skeletal remains to establish ID (which, in New Mexico, became available in 1996) had no statistically significant effect on ID rates. In this study, the ID rate for all cases pre-1996 ($n = 520$) was 76%, increasing slightly to 79% for the post-1996 cases ($n = 253$).

Distributions based on percentage of body recovered also varied between the current study and past reports. Although complete bodies represented the greatest proportion (29%) of the remains described here, the largest percent of cases (28.1%) described by Grisbaum and Ubelaker (4) involved only 10% of the entire skeleton, followed by 5% of the skeleton (11.1% of their sample). Complete skeletons comprised only 2.7% of their sample. Differences in sampling account for the observed difference: Grisbaum and Ubelaker's study reported the amount of material submitted for analysis, while this study examines the total amount recovered.

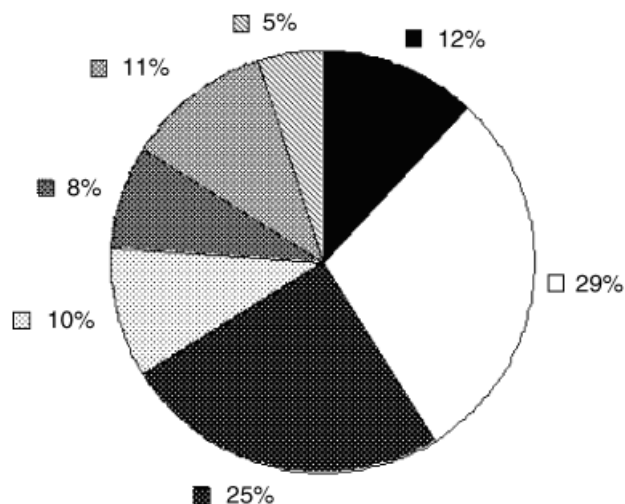


FIG. 1—Percentage of total body recovered ($n = 773$). ■, Unknown* ($n = 97$); □, complete ($n = 221$); ■, 76–99% ($n = 193$); ■, 51–75% ($n = 74$); ■, 26–50% ($n = 59$); ■, <25% ($n = 87$); ■, 1 element only ($n = 42$). *Autopsy and anthropology records contained insufficient inventory or information.

TABLE 2—Effect of percentage of body recovered on identification (ID) rate and cause of death (COD)/manner of death (MOD) determination.

Percentage of Body Recovered	Positive ID	COD Determined	MOD Determined
Complete ($n = 221$)	196 (89%)	184 (83%)	174 (79%)
> 50%* recovered ($n = 488$) [†]	393 (81%)	343 (71%)	329 (68%)
< 50% recovered ($n = 188$) [‡]	109 (58%)	78 (41%)	77 (41%)
Skull recovered ($n = 659$) [‡]	572 (87%)	461 (70%)	428 (65%)
No skull ($n = 66$) [‡]	40 (61%)	25 (38%)	26 (40%)
Total sample ($n = 773$)	597 (77%)	506 (66%)	482 (62%)

*Includes complete bodies.

[†]Ninety-seven of the 773 total cases had incomplete inventories and the total body percent recovered could not be determined.

[‡]Forty-eight cases of the 773 included in the total sample had insufficient inventories to determine whether a skull was recovered.

Complete remains were also reported in only 10% of a smaller sample ($n = 20$) of decomposed remains recovered in Edmonton, Alberta (5). Skulls were recovered in 95% of these cases. Bass and Driscoll (8) reported that skull or skull bones were the most common element recovered.

The importance of skull recovery to ID has been discussed previously (for example, Haglund (12)). In skeletonized remains, ID is most often established through dental analysis (13,14). Significant trauma to the skull (i.e., multiple blunt force injuries or gunshot wounds) provides sufficient morphological evidence for cause of death determination (15). The negative impact of failing to recover the skull is demonstrated in this study, with statistically significant decreases in ID rates and cause and manner of death determination. This association remained significant ($p = 0.0118$) regardless of the percentage of postcranial remains recovered.

As mentioned previously, anthropological analysis is often conducted separate from the medicolegal autopsy and anthropologists do not consistently receive follow-up information on cases (4). Further, anthropologists do not rule on cause or manner of death, as this is the responsibility of the forensic pathologist. Therefore, most summaries of anthropological cases do not report cause or manner of death rulings. The cause of death was determined in 50% of skeletal cases in a small sample from Alberta (5), lower than the overall rate (66%) seen in this study. However, many reviews of anthropological cases do note the incidence of trauma on recovered elements. For example, Grisbaum and Ubelaker (4) report that only 40.7% of their sample had no evidence of trauma, while Boles et al. (10) observed traumatic injuries to all 12 individuals recovered from mass graves in Guatemala. Ubelaker et al. (11) noted trauma in 37% of the 83 Branch Davidian victims who received an anthropological exam. The presence of trauma, however, does not inherently lead to the determination of a cause of death. In this study, the cause of death could be determined for 66% of all individuals, while 69% had some form of trauma evident at autopsy.

Skeletal and decomposed cases make up a small part (*c.* 2%) of the total number of death investigations conducted each year by the New Mexico Office of the Medical Investigator (roughly 4700–5100 per year). It is interesting to note how these anthropological consult cases compare with the general autopsy/death investigation cases in terms of ID rates and cause/manner of death determination. Summary statistics for the total sample of OMI general death investigations for the years 1997–2004 (16–23) are provided in Table 3. The rate of positive ID shows a statistically significant difference between the general death investigation sample (94–96%) versus the skeletal/decomposed sample (77%). ID rates in the general sample were similar to those reported by a

TABLE 3—Descriptive statistics from general autopsy/death investigation cases from the New Mexico Office of the Medical Investigator, 1997–2004.

Total Number of Cases	38,909
Positive identification rate	94–96%
Cause of death determined	98.5–99.3%
Manner of death determined	96–99%

similar-sized medical examiner's office in Cape Town, South Africa (24). Significant differences were also seen in cause (98.5–99.3% in the general sample vs. 66% in the skeletal sample) and manner of death (96–99%, general vs. 62%, skeletal) determination rates. Percentage of body recovered plays an important role in the higher rates of ID and cause/manner determination evident in the general sample. With the exception of a small number of burned or badly traumatized individuals, all bodies contained within the general death investigation sample were fully fleshed and complete. Other contributing factors include the potential for visual ID in fleshed remains and the ability to discern cause of death from soft tissues. Factors limiting the resolution of skeletal or decomposed remains include the potential loss of information normally derived from the scene (such as clothing or personal effects) or remains (such as evidence of trauma) over time as the result of taphonomic variables such as animal scavenging. The often lengthy postmortem intervals seen in decomposed or skeletal cases may also impact ID efforts, as dental and medical records can be lost or destroyed, fingerprints are obliterated, and the ability to extract DNA samples successfully can decrease over time (25,26).

Significant differences are also seen in the percentages of the manners of death ruled between the two samples (see Table 4). Dramatic disparities in the percentages of undetermined, homicidal, and accidental deaths were noted, while the proportions of suicide and accidental deaths varied between samples but not significantly. Although the loss of soft tissue or skeletal elements can obscure evidence of traumatic injury, the effect is also seen in natural deaths. Evidence of pathological conditions lost with the decomposition of soft tissue can transform an otherwise easily identified natural death into a case of undetermined cause and manner.

The results of this study indicate that the percentage of remains recovered does have a significant effect on ID rates, as well as the ability to determine cause and manner of death. The recovery of the skull, regardless of the percentage of the postcranial remains found, also significantly impacts ID and ruling rates. As recovery of skeletal remains is often incomplete because searchers fail to recognize them (1), the findings of this study argue for the participation of anthropologists in the recovery of all decomposed and skeletal remains cases to maximize recovery rates. Finally,

this report quantifies the effect of incomplete body recovery on downstream death investigation, providing data to serve as the basis for courtroom testimony and comparative analysis with other geographic regions or autopsy samples.

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TABLE 4—Comparison of manner of death (MOD) ruled for general autopsy versus anthropology consult cases involving complete bodies.

MOD	General Autopsy (Total Number of Cases, n = 38,909) (%)	Anthropology Consult (Complete Bodies, n = 221) (%)
Natural	61–63	8 (n = 18)
Accident	22–23	20 (n = 43)
Suicide	7–9	7 (n = 16)
Homicide	4–5	44 (n = 97)
Undetermined	1–4	21 (n = 47)

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