Lost, But Not Alone:

Burial records as a means of determining absolute taphonomic loss by age in cemetery populations.

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Abstract: The rate of loss of human bone in burial contexts is a topic which is of interest to archaeologists and forensic scientists alike. In excavated cemeteries it is frequently contended that large portions of the initial burial population, especially children, are rapidly lost through taphonomic processes. Burial records are one under-utilized means of assessing this attrition in cemetery populations. Such records provide a glimpse into the health risks of the population and furnish an initial mortality estimate, which allows for the study of taphonomic loss. Three excavated historic period cemeteries (St. Benet Sherehog, London N=230; Alameda Stone, Tucson N=1166; and the Voegtly Cemetery, Pittsburgh N=546) were compared to associated parish burial records (St. Benet Sherehog N=1513; San Agustin N=5099; and Voegtly Church N=806). The resulting mortality profiles were fitted against Model West life tables. Though very demographically different from one another, all cemetery records demonstrated plausible infant (0 - 1.9 year-old) mortality rates, ranging from a relatively high 52% to a moderate 21%. Mortality estimates derived from the osteological evidence in this age category were consistently 5 - 10% lower than those obtained from burial records for the same cemetery. The absolute loss of individuals varied markedly between samples. However, it was found to be quite similar across age groups within each cemetery, with attrition in the infant category only 3 - 15% greater than losses among adults.

Keywords: Biological Anthropology, Historic Cemeteries, Demography, Taphonomy, Archaeology

Introduction

The extent of taphonomic loss to human bone in burial environments is poorly understood. It is frequently argued that juvenile remains do not survive in burial contexts as well as adult remains (BAKER et al., 2005). This is confounding to archaeologists, as it is widely accepted that infant mortality, and therefore infant remains as a proportion of the total quantity of skeletal remains buried in cemeteries, must have been much greater in historic and ancient populations than it is today (SAINZ DE LA MAZA KAUFMAN, 1997; CALDWELL, 1996; GUY et al., 1997; CALDWELL & CALDWELL, 2003; LEWIS & GOWLAND, 2007). Despite repeated assertions that infant mortality was high, much like taphonomic loss, its extent has never been fully quantified. In skeletal samples from excavated cemeteries, infants have been found to make up 30% of the population or less (BUCKBERRY, 2007). While this is not as low as modern estimates of infant mortality, it is not as high as the estimates of ~35-40% and above which have been postulated by archaeologists and historical demographers (COALE & DEMENY, 1983; CALDWELL, 1996; HOLLINGSWORTH, 1968; LEWIS & GOWLAND, 2007). The persistent feeling that child mortality is in some

way unknowable hampers the demographic study of ancient populations. If infant mortality is consistently thought to be "high", while recovery from cemetery contexts is demonstrably "low", a paradox is created in which it is extremely difficult to study the material culture of burials; and correspondingly difficult to study larger demographic questions. These two types of queries are important to our understanding of post-mortem osteological processes, as well as the wider study of ancient populations.

Infant mortality is one of the best indicators of the health of any population, and so is of great interest to archaeologists (ACSADI & NEMESKERI, 1970; CHAMBERLAIN, 2006). Comprehension of taphonomic processes, which must be understood first, is crucial to a number of fields in addition to the study of demography. People have long debated the survivability of bones in post-mortem contexts, from both the recent perspective of forensic science to the more venerable time-scale of paleontological research (MANT, 1987; ARCHER, 2004; MORTON & LORD, 2006; CARTER et al., 2008, 2010; URURAHY-RODRIGES et al., 2008; STOKES et al., 2009; ROSS & CUNNINGHAM, 2011; UBELAKER & ZARENKO, 2011; VON ENdt & ORTNER, 1984; SILLEN, 1989; WILLEY et al., 1997; NIELSEN-MARSH & HEDGES, 2000 a & b; STINER et al., 2001; DENYS, 2002; JANS et al., 2004 NIELSEN-MARSH et al., 2007; SMITH et al., 2007; TURNER-WALKER & JANS, 2008; FERNÁNDEZ-JALVO et al., 2010). If infant bones disappear more rapidly and completely, is it owing to chemistry, physical processes, or poor recognition and hence lowered potential for recovery? If infant remains are not lost at a greater rate than those of adults, why has this notion that they are missing persisted for so long? To the credit of archaeologists, the question is not easy to resolve. It is known that the decomposition of bone is influenced by a broad range of interacting factors including element size; bone density; soil acidity; hydrological conditions; temperature; burial depth and duration; whether the body is buried with adhering flesh; the extent of exposure or preservation of the body before burial; and disturbances ranging from root infiltration, to animal burrowing, to grave reuse, to overbuilding (ibid.). Attempts to study infant mortality and the preservation of their remains have been limited by these numerous variables, and the paucity of samples available for study (see GORDON & BUIKSTRA, 1981; WALKER et al., 1988; LANPHEAR, 1989; GRAUER & MCNAMARA., 1995; SAUNDERS et al., 1995; GUY et al., 1997; BUCKBERRY, 2007; BELLO et al., 2006; DJURIC et al., 2011; MANIFOLD, 2013).

One largely untapped method of addressing these questions is the comparison between the demography from burial records and excavated cemeteries. Three excellent candidates for this type of research are the Alameda Stone Cemetery, St. Benet Sherehog, and the Voegtly Cemetery (UBELAKER & JONES, 2003; MILES & WHITE, 2008; HEILEN & GRAY, 2010). These samples are superior to previously analysed populations in a number of ways: Firstly, all have thorough associated burials records (BANNERMAN & BANNERMAN, 1920; UBELAKER & JONES, 2003; THIEL, 2012). This is important because the use of less closely linked demographic records such as censuses and city wide mortality schedules may give a broader sense of a large population, but may be insufficiently specific to compare smaller populations. Second, none of the cemeteries in this study were poor houses, military cemeteries or other selective populations that may show strong age or sex biases. Finally, all were large, recently excavated samples. Many of the most commonly quoted sources on infant recovery- Walker and colleagues included- were based on samples excavated well before the 1980s. Recent samples are superior in that excavators now recognize the importance of excavating and assessing remains as best as possible, regardless of age or preservation.

Materials & Methods:

Three historic cemeteries with associated burial records were studied. These were St. Benet Sherehog (N=230); Alameda Stone Cemetery (N=1166); and the Voegtly Cemetery (N=546) (UBELAKER & JONES, 2003; MILES & WHITE, 2008; HEILEN & GRAY, 2010). The burial records were derived from the Parish of St. Benet Sherehog & St. Steven Walbrook (N=1513), San Agustin Parish (N=5099), and Voegtly Church (N=814) (BANNERMAN & BANNERMAN, 1920; UBELAKER & JONES, 2003; THIEL, 2012). The samples ranged in date from 1670 to 1875 with some temporal overlap between all of the burial grounds (Tab. 1).

CEMETERIES	DATE (A.D.)	SAMPLE SIZE	LOCATION
St. Benet Sherehog	1670-1850	230	London, UK
Alameda Stone	~1851-1875	1166	Tucson, AZ, USA
Voegtly Church	1833-1861	545	Pittsburgh, PA, USA
RECORDS			
Parish of St. Benet Sherehog & St. Stephen Walbrook	1716-1849	1513	London, UK
San Agustin Parish	1875-1909	5099	Tucson, AZ, USA
Voegtly Church	1834-1861	806	Pittsburgh, PA, USA

Tab. 1 – Populations Used in this Study

These cemeteries were chosen because they were large, recently excavated graveyards with thoroughly analysed and widely disseminated reports. In addition, each of the burial grounds is considered to have been completely excavated. All had associated parish burial records which were fairly complete. This enabled a direct comparison between the osteological sample and an approximation of the demographic composition of the population which was initially buried.

St. Benet Sherehog was a small London Anglican parish whose population was in gradual decline during the use of the excavated cemetery in question (MILES & WHITE, 2008). Located at 1 Poultry, the cemetery was fully excavated in 1994-1996 by the Museum of London Archaeological Service. The osteological sample included 187 individuals of known age, and 43 adults of unspecified age, for a total sample of 230. The cemetery records used are the combined burial records from the Parishes of St. Benet Sherehog and St. Stephen's Walbrook. Of the 1,687 burials recorded, 30% (N=507) were known to have been buried at St. Stephen's, while only 5% (N=84) were known to have been buried at St. Benet Sherehog. The remaining 65% have an unspecified burial place in one of the two cemeteries. Although the Post Medieval portion of the cemetery was in use from 1670 onwards to 1850, the burial records spanned only the years of 1716-1850 (BANNERMAN & BANNERMAN, 1920). Of the total burials, 304 had imprecise but salvageable age categories such as infant, child, and adult. One-hundred-fifty-six individuals were excluded from the sample because their ages were completely unknown, leaving a sample size of 1,513.

The Alameda Stone cemetery was the only cemetery serving the population of Tucson, Arizona from 1851 to 1875 (HEILEN & GRAY, 2010). When the cemetery was in use, Tucson was an expanding frontier city,

characterized by a mixed-race population of railroad workers, ex-soldiers, ranching families, and traders. Excavated in 2006 by SRI Corporation, the minimum number of individuals in the skeletal assemblage was 1,166. In the course of this project, the cemetery was completely cleared. Historical exhumations of some graves took place in 1882 and 1884 shortly after the closure of the cemetery. The construction of the Tucson Newspaper Building in 1953 is also known to have disrupted a number of bodies prior to the excavation of the cemetery. At least 48 individuals were removed during the latter. The number removed during the former is unknown (ibid.). The burial records studied were from the parish of San Agustin, which served the largely Catholic population of Tucson (THIEL, 2012). They include 5,099 individuals. The records were from slightly later period of 1875-1909. However because of the short use-period of the cemetery, it is unlikely that the composition of the dying population shifted drastically during this time. Alameda-Stone almost certainly had a Catholic section. It is also probable that the Catholic diocese, as the central religious organization of Tucson at the time, recorded many of the non-Catholic deaths in the city.

The Voegtly Cemetery served a Swiss-German Anabaptist population in Pittsburgh (then Old Allegheny Town), Pennsylvania from 1833-1861 (UBELAKER & JONES, 2003). During the burial ground's use, the area transitioned from a relatively prosperous Swiss-German suburb to an industrialized melting pot. Excavated in 1987 by GAI Consultants, Inc. and the Smithsonian, it was the earliest field project included in this study. Despite this, its excavation, analysis, and reporting were very thorough. At least 8 burials were known to have been disturbed or destroyed during construction in 1911, and a further 3 were exhumed after the cemetery's closure. Though a total of 724 features and 689 individuals were identifiable, bones were present for only 554 of these. Only those burials with bones present were utilized in this analysis. Nine sets of foetal remains were also excluded from general analysis. Of 896 individuals listed in the Voegtly Church burial records (1834-1861), only 823 were interred at the Voegtly Church (ibid.). Of these, only 806 had a known age at death, including 39 with non-specific ages. These individuals make up the sample. It is suspected by the translators of the records that some of these unaged burials, with the notation of "not seen" or "not displayed" may represent stillbirths or miscarriages.

The ages derived from the excavated cemetery populations and the burial records were divided into six age categories: 0-1.9, 2-11.9, 12-17.9, 18-34.9, 35-49.9, 50-99.9 years. These categories were chosen because the reporting of ages in the Alameda Stone Cemetery limited their further subdivision in the adult groups, and because they facilitate useful comparison with other data sets. The juvenile osteological age categories in use at St. Benet Sherehog ("Neonate", 1-5, 6-12, and 13-17 years) were also a limiting factor. Where they overlapped with the age groups used in this study, they were divided by the number of years in their original category. Some of the individuals were then reapportioned into the younger or older age category as appropriate. Despite lacking the detail to inform changes in preservation which may exist within the first year of life, the age categories in this study were generally suitable to study differences between infants, children, and adults. Analysis of the burial records, which often aged young individuals to the month, enabled a more refined understanding of age-specific mortality within each population. No individuals were included whose ages were estimated with indirect methods, such as those guessed by grave or coffin size. Individuals with completely unknown ages were excluded from both the records and osteological population. In the cases where ambiguous age categories were present, such as "Adult", "Child" or "Infant", they were divided and

stacked into the most likely age sub-category. This was most prevalent in the burial records for St. Benet Sherehog (BANNERMAN & BANNERMAN, 1920).

Because developmental age was not more precisely listed in excavation reports, and death by month in utero could not be assessed, foetal remains were eliminated from the initial osteological analysis. However recorded stillbirths were included in the infant age category, as they were under-enumerated and potentially hidden in the burial records from San Agustin Parish and St. Benet Sherehog (BANNERMAN & BANNERMAN, 1920; THIEL, 2010). While this has the effect of increasing the appearance of infant loss, it prevents the accidental exclusion of full term infants who simply did not survive the birthing process in the representation of the population's initial mortality. Foetal remains recorded during the excavation of St. Benet Sherehog, had been merged with 1-4 week old individuals into a "Neonate" age category in the report. An additional 15% of the 1-5 year old age group from the St. Benet Sherehog report was also stacked into the 0-1.9 year old category during analysis as a conservative approximation of the 5 week to 1.9 year olds who were not more clearly enumerated in the osteological report. This, along with the fact that St. Benet Sherehog shared parish records with St. Stephen's, is likely to inflate the appearance of loss in the youngest age category.

	Stillborn from Burial Records	Foetal Remains
St. Benet Sherehog	9	0
Alameda Stone	2	67
Voegtly Cemetery	40	9

Tab. 2 – Stillborn Population from Records & Foetal Remains from Excavation

Once the osteological and parish record data for each site was compiled, it was compared to Model West Life tables to assess the plausibility of its distribution (COALE & DEMENY, 1983). Such tables are derived from modern populations with various mortality structures. Three Life Tables, Levels 9, 5, and 1 were used to reflect the different mortality patterns within each population. For all life tables, growth rate (r) was estimated at 0.5% per annum, while average life expectancy at birth (E0) varied, depending on infant mortality and the post-infancy survivorship pattern.

Results

The three cemeteries studied had widely divergent mortality profiles, each of which was plausible as compared to Model Life tables.

St. Benet Sherehog

The demographic profile of St. Benet Sherehog is presented in fig. 1. Of the three populations studied, it was the healthiest in terms of estimated life expectancy at birth. Although it was not an extremely wealthy parish, perhaps the amenities of a large urban centre made up for some of the difficulties experienced by its industrializing and frontier counterparts in America. The age at death profile reconstructed from the burial

records most closely resembled a Level 9 Model Life Table with an average life expectancy at birth (E0) of 40 years and an annual growth rate (r) of 0.5%. It had the lowest proportion of infant deaths of all the samples (20.8%). Most of these deaths were clustered around the time of birth, indicating unsanitary birthing practices, congenital disorder, or enfeeblement.
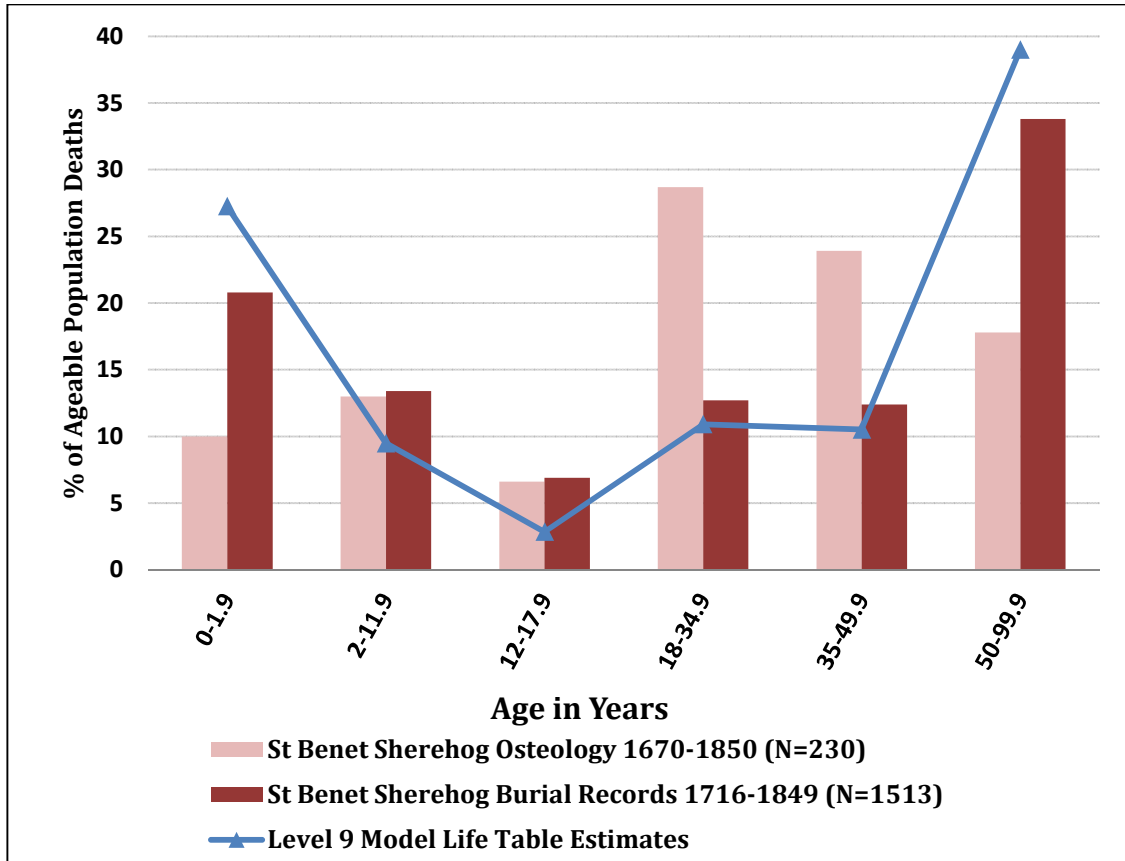

Fig. 1 – Proportional Mortality by Age at St. Benet Sherehog Compared to Model West life Table 9

The osteological samples of adult individuals displayed an excess of deaths in the 18-35 year age group and a corresponding deficit in the >50 years category when compared to the profile generated from the burial records. This is most likely the result of enumeration errors due to the difficulty of accurately aging individuals ~40 years old and older using skeletal indicators. From the parish records, it is known that many individuals in this community survived well into their 70s and 80s. Compared to the Model West Tables, both early and late life mortality are slightly lower than expected. Despite this, the apparent loss between burial and recovery in the infant age category is the highest of any of the burial grounds studied (~10%). This is most likely because the records include two parishes with two distinct burial places, while only one burial place was excavated.

The Alameda Stone Cemetery:
The demographic profile for Alameda Stone is presented in fig. 2. The Alameda Stone Cemetery was compared with a Level 5 Model West Life Table, with an average life expectancy at birth of 30 years, to reflect the much higher level of infant mortality within this population. At almost 37%, infant mortality in this

population was the second highest in this study. Unlike St. Benet Sherehog, much of Alameda Stone's infant death was concentrated around the age of a year. This may be associated with weaning hazard and the gastrointestinal diseases which would be expected to disproportionately affect south-western populations. While over-enumeration still occurred in the earlier adult age categories, its
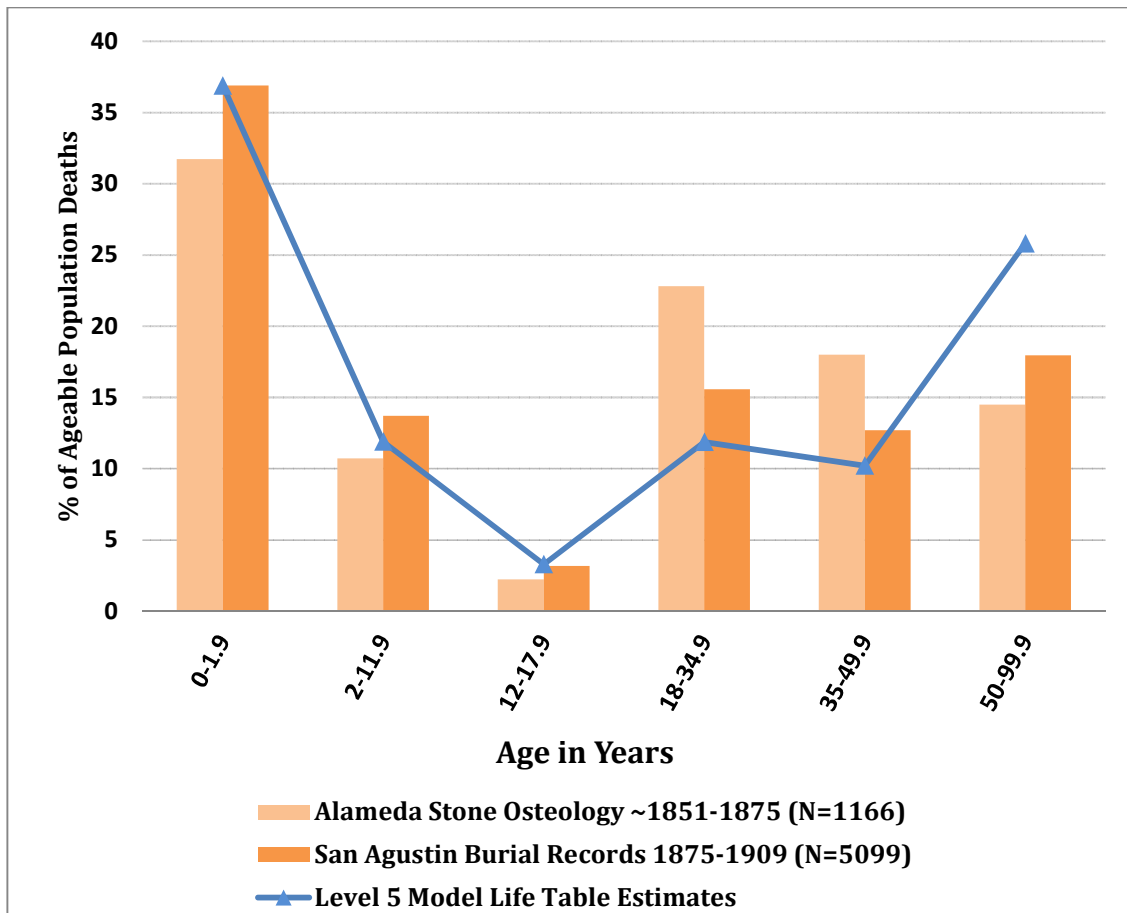

Fig. 2 – Proportional Mortality by Age in the Alameda Stone Cemetery Compared to Model West Life Table 5

extent was not as great as for St. Benet Sherehog. This may be owing to the fact that fewer people in this population survived into advanced age, as well as the fact that St. Benet Sherehog included more "unageable" adult individuals, who were stacked more evenly across the age categories. Compared to the Model West Tables, the profile of adult mortality is slightly abnormal: higher than expected among younger adults, and lower than expected among the elderly. This may reflect the risk of accident and violence in the "Wild West": a phenomenon which has been observed in neighbouring historical accounts and cemeteries.

The Voegtly Cemetery:

The demographic profile for the Voegtly Cemetery is presented in fig. 3. The mortality profile
for Voegtly Cemetery reconstructed from burial records was very similar to a Level 1 Model Life Table, which reflects its very high infant and child mortality (52% and 17% respectively). This was the highest of all the cemeteries, even slightly exceeding the Model Life Table which it most closely matched. Its child mortality (2-11.9 years) was also higher than any other population, dropping off in adolescence (12-17.9 years) to the

very low figure of 2%. The appearance of infant mortality in this population may be inflated by the high number of stillbirths recorded in the parish records. As with the other populations, some over-enumeration of young adults and under-enumeration of the geriatric persisted. However it was less pronounced than in either of its counterparts, due to the proportionally high infant mortality and correspondingly low mortality among the elderly. During this time, Old Alleghany Town had a growing population. It was an emerging centre of trade and manufacturing, which brought with it prosperity as well as increasingly urbanized conditions and labour.
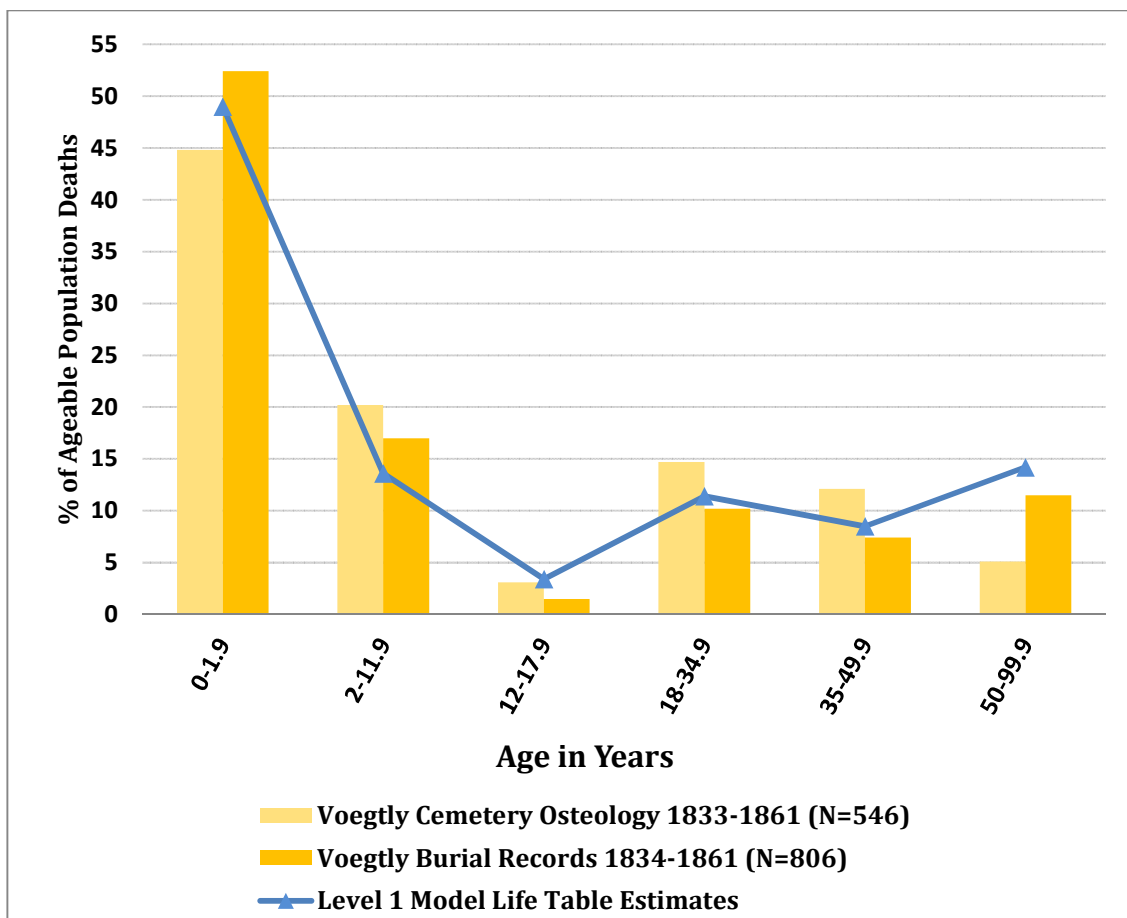

Fig. 3 – Proportional Mortality by Age in the Voegtly Cemetery Compared to Model West Life Table 1

Stillbirths & Foetal Remains:

The inclusion of osteologically-determined stillbirths was attempted in order to see to what extent this would diminish the appearance of loss in the infant category. As St. Benet Sherehog's foetal remains were already merged with infants in the reporting of the osteological sample, no change could be studied. The results are presented in fig. 4. As anticipated, the inclusion of stillbirths in the infant age category reduced the appearance of the loss of infants in both populations. Voegtly Cemetery displayed a 2% difference, while Alameda Stone had a discrepancy of 4% between the two osteological estimates.
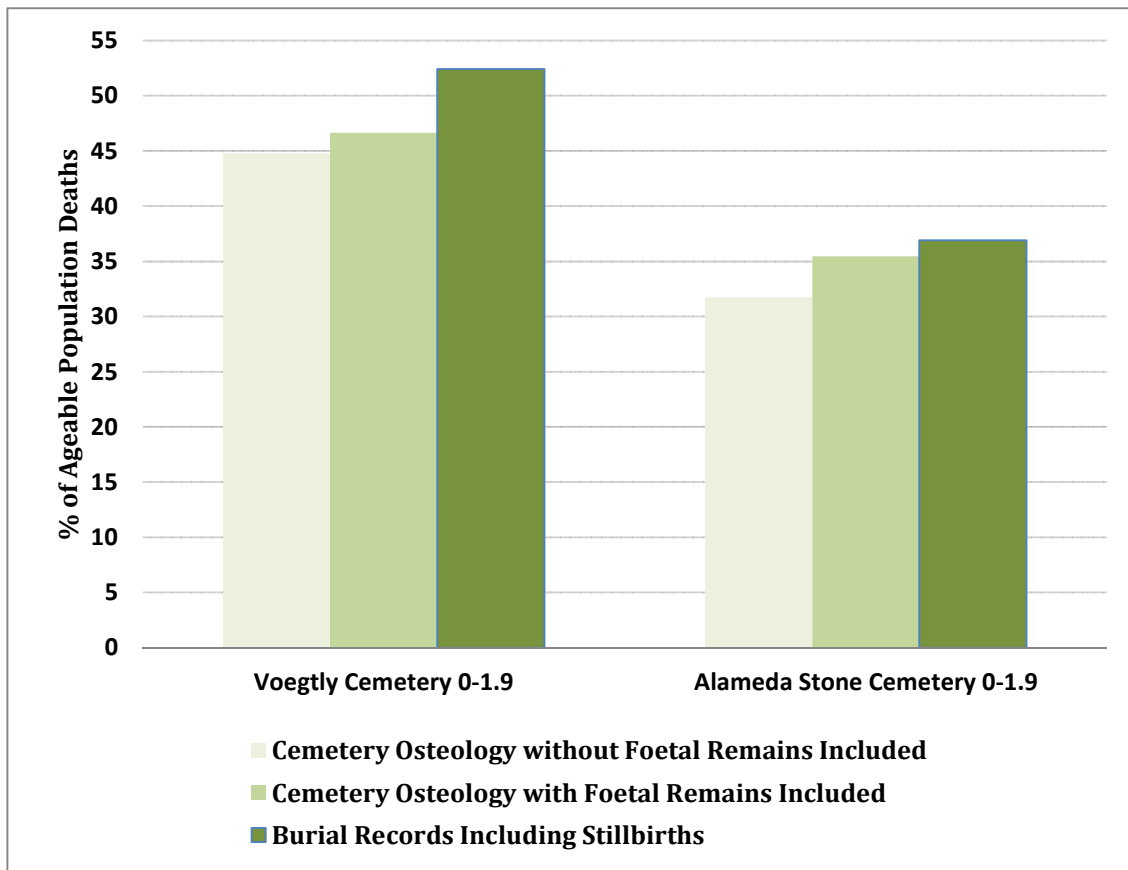
Fig. 4 – Proportional Loss to Infants Including Foetal Remains

The proportional loss or gain of infants from the total cemetery population only reflects one aspect of taphonomic activities. It would be possible, for example, to witness a rise in the proportion of infants from burial to excavation if no infants were lost, while losses to adults were severe. Comparing proportional loss by discrete age group is most useful for determining to what extent the demographic profile of the skeletal assemblage from the cemetery maintains its initial distribution as shown by documentary records. In all examples in this study, proportional change is relatively minor and predictable among the young, but more inaccurate among adults who tend to be incorrectly aged. In order to determine whether infants are actually lost with higher frequency than adults, the percent total loss or gain from each age category must be studied from the original number in each age category (infant, child, or adult) from the burial records. To determine whether the total loss of infants was comparable to the loss of adults and children, the 2-17.9 year olds were grouped together, and all adult age categories were grouped. The loss within each age group was then tabulated. The results are presented in fig. 5.
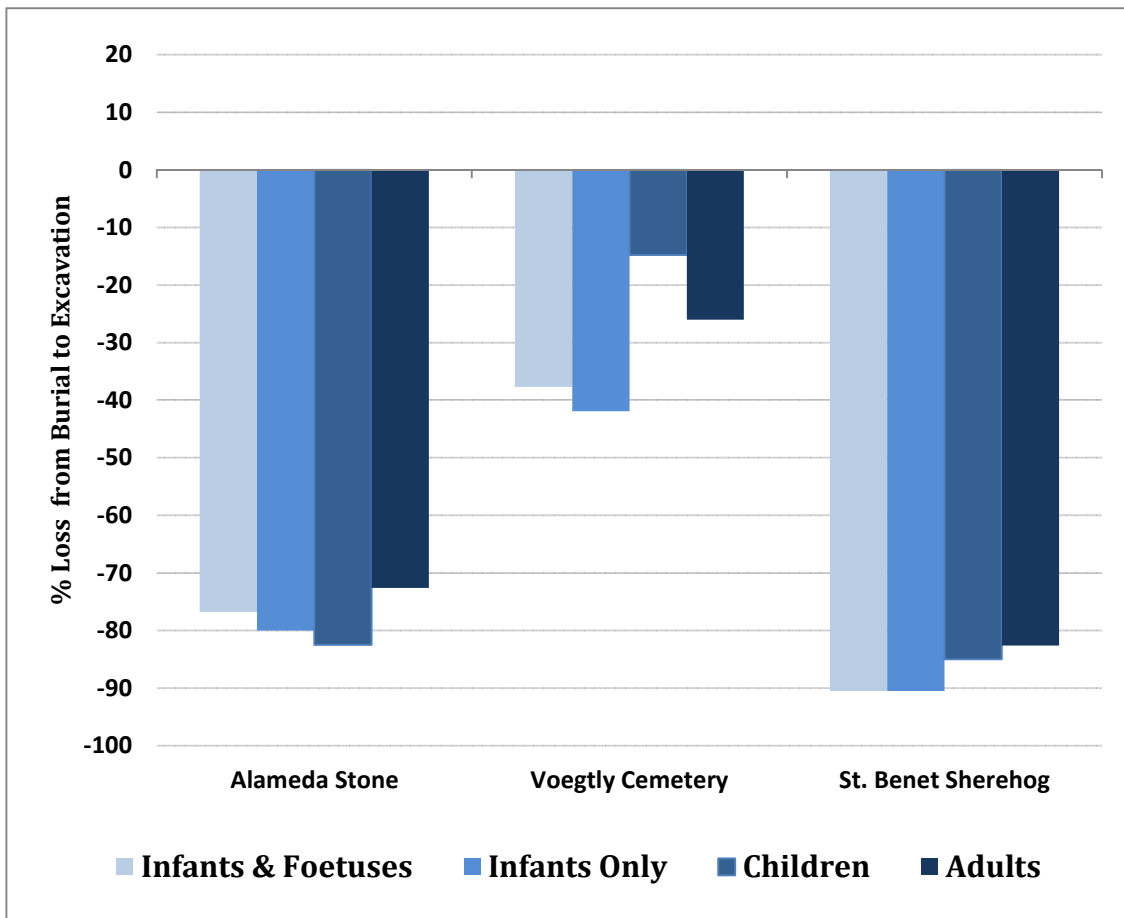
Fig. 5 – Absolute Loss Among Infants, Children, and Adults

The three cemeteries had variable loss rates for infants. Alameda Stone and St. Benet Sherehog were similarly high: 80% and 90% loss respectively. The loss of infants at Voegtly Cemetery was a lesser 40%. Despite these different rates of loss between cemeteries, within each cemetery, the rate of loss was actually quite similar for infants, children, and adults. In the case of Alameda Stone, the loss of children was actually greater than either infants or adults. Although the loss of infants tended to be slightly higher than the loss of adults in all samples, it was never more than a difference of 13%. The inclusion of foetal remains slightly reduced the appearance of infant loss, save at St. Benet Sherehog where no foetal remains were enumerated.

Discussion

The three cemeteries in this study were quite demographically different from one another according to their burial records. At 21%, St. Benet Sherehog had the lowest infant mortality. From the records, it is also known that the adults in this population enjoyed the greatest chance of longevity, with many individuals surviving into their 70s and 80s. Age-specific infant deaths in the records clustered around birth, implicating congenital disorder or unsanitary birthing practices. San Agustin had the second greatest infant mortality. It was a relatively high 37%, even taking into account the fact that most who reached adulthood still died before achieving the age of 60. Of these deaths, more took place in early adulthood than was the case in the other

cemeteries. This is possibly a reflection of the risks of frontier life. Unlike St. Benet Sherehog, the bulk of its infant deaths were clustered late in the second year of life, likely indicating weaning hazards and disease in Arizona's hot climate.

Voegtly Cemetery had the highest infant mortality of all (52%). Childhood mortality in this sample was also higher than the other populations, while death among the geriatric category was proportionately reduced. Of the populations, Voegtly appears to be the least healthy from the demographic profile, with the fewest individuals surviving to adulthood. This may be a reflection of the industrializing conditions of the city at the time, which may have been particularly deleterious to infants and children as they lost caregivers to industry or entered into dangerous employment conditions themselves. Urban living conditions are also hazardous to the young, with poor sanitation, heightened exposure to epidemic diseases, and increased risk of respiratory ailments contributing to mortality. Infant mortality in this population may also be artificially inflated due to the high number of stillbirths in the parish records, compared to its contemporaries whose inclusion or exclusion of stillbirths is uncertain.

The comparatively few stillbirths recorded for Alameda Stone and St. Benet Sherehog may imply a) that fewer stillbirths occurred in these parishes b) stillbirths were buried/disposed of in some other way or c) those who were stillborn were included in the burial records and either intentionally or incidentally not recorded specifically as stillbirths. The former may have been a way of circumventing Anglican/Catholic doctrine that discouraged the burial of unbaptised infants in consecrated ground. The osteological evidence from all cemeteries would suggest that stillbirths were buried. This is also implied by other burial records from the time period which recorded family members providing lay baptisms for neonates whose death seemed imminent. The Hispano-american belief in "los angelitos", small children whose purity assured that they would surpass purgatory and go directly to heaven, further substantiates these assertions (HEILEN & GRAY, 2010).

Comparison to Model West Life Tables resulted in plausible matches for the mortality profiles of each cemetery based on the available burial records. This indicates that mortality may vary greatly between populations and still be credible. Furthermore, the similarity of the excavated samples to the initial mortality profiles means that researchers may trust to a large extent the proportion of infant mortality represented by a thoroughly excavated burial population. Examining associated records can make researchers even more confident in this knowledge. This is especially true when probable causes behind age-specific death within a population are obvious from the records. Even within a population, high mortality in one age category may not correspond with overall high mortality. Alameda Stone is an example of this, with high infant mortality and a reasonable number of elderly adults. By contrast, high early life mortality in Voegtly Cemetery corresponded with earlier death among adults, with only around 10% surviving above the age of 60. The absolute loss of individuals in any given age group ranged between samples from 14 - 90%. Despite this, it was similar between age groups in any given cemetery. Losses to infants were slightly higher than adults, however only by 3 - 14%. In the case of the Voegtly cemetery, the loss of children was actually greater than the loss of infants. This seems to imply that where losses are high in one age category, they will be high in all.

There are several caveats to these promising results. The necessity of accurate and fairly precise aging for the entire population in excavated cemeteries is of paramount importance. Without the presence of this data,

demography cannot be studied. Because cemeteries are often organized in sections, an incompletely excavated cemetery may also be skewed. It is important to study cemeteries which have had large percentages of their original burials cleared using archaeological methods, or which at least involve a large sample size taken from different areas. Since there are a range of realistic mortalities, it is also important to consider each cemetery in context. One would not expect the mortality in a suspected plague pit or military cemetery to be perfectly average.

Conclusions

Each group of cemetery records within this study demonstrated plausible infant (0 - 1.9 year-old) mortality rates as compared to Model West Life Tables. These ranged from 52% to 21%. Mortality estimates derived from the osteological evidence in this age category were consistently 5 - 10% lower than those obtained from burial records for the same cemetery. The absolute loss of individuals varied markedly between samples. However, it was found to be quite similar across age groups within each cemetery, with attrition in the infant category only 3 - 14% greater than losses among adults.

From this, we can conclude that the mortality profile of an excavated cemetery may fairly closely resemble the actual mortality profile of the cemetery. However, researchers should beware over-enumeration in early adulthood, and minor losses among juveniles. While the absolute loss of infants does appear to be slightly greater than that of adults, it is not excessively so. In some cases, the loss to children may actually be greater. A more persistent trend than loss in any one age category seems to be the overall similarities between infants, children, and adults in a given cemetery; where loss is fairly high in among one group, it appears to be high among all of them.

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