

RECONSTRUCTING THE HISTORY OF KOCH CEMETERY

A Late 19th to Early 20th Century Cemetery from St. Louis, Missouri (Site Number: 23SL452)

by

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ABSTRACT

This project examined commingled and fragmentary skeletal remains from Koch Hospital Cemetery in St. Louis, Missouri, where thousands of epidemic victims were buried in mass graves. The primary research objectives were twofold: 1) to use archival research to construct a site history and understand patient demographics, and 2) to decommingle and estimate collection population. Archival research was conducted using Ancestry LE and Newspapers.com to understand the demographics of the dead and the social dynamics of healthcare during the 19th and 20th century. Zooarchaeological and forensic anthropological methods were used to estimate the minimum number of individuals (MNI) and most likely number of individuals (MLNI). The number of elements was calculated using modified forms of zooarchaeological zonation and landmark analyses. Results show a MLNI of 40 ± 18 , with a comparative MNI of 17 individuals. The MLNI estimate is likely more accurate because the method compensates for a low recovery rate and fragmentation. Statistical analyses of archival death records revealed a significant disparity between sexes and racial/ethnic groups in age at time of death: black individuals died 10.9 years younger than white individuals ($p = 0.0001$) and females died 7.4 years younger than males ($p = 0.0005$). St. Louis' largest newspapers, the *St. Louis Post-Dispatch* and *St. Louis Globe-Democrat*, reported significantly higher death rates amongst people of color during epidemics. While many individuals buried at Koch were immigrants, all were of low socioeconomic status, with less access to and a lower quality of healthcare than higher socioeconomic status individuals. Koch Cemetery demonstrates how disproportionately the most marginalized populations of St. Louis were affected by infectious disease during the late 19th and early 20th centuries.

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CHAPTER I

INTRODUCTION

During the late 19th and early 20th centuries in St. Louis, Missouri, vulnerable groups of the city's most marginalized individuals were struck by repeated epidemics. Many of the sick who were well enough to leave their homes were sent 15 miles south of the city, to a makeshift quarantine zone, now known as Koch Cemetery. The city purchased this land in 1854 for use as a makeshift treatment center for patients with infectious disease (Bass and Eberle 1984). This treatment center was known as Quarantine Station from 1854 to 1907. In 1910, construction began on a new hospital for the treatment of tuberculosis (TB), Koch Hospital, which was operational until the 1950s, after which it was used as a nursing home. While the hospitals on this property were used to treat the sick, the land began to function as a cemetery for those who did not survive. By the end of the Quarantine Station in 1907, at least 18,000 people had been buried in Koch Cemetery, many in mass graves (Bass and Eberle 1984).

Koch Cemetery's proximity to the Mississippi River made the land unstable and prone to sink holes (**Figure 1**). As the Quarantine Station and Koch Hospital each became overwhelmed by the sheer number of deaths, the facilities administration took advantage of these sink holes to bury the dead. Over the years, the land has continued to deteriorate, exposing human remains. In the late 1960s, faculty from the University of Tennessee, Knoxville were called to St. Louis to excavate some of the exposed remains. They recovered more than 700 highly fragmentary and commingled bones from the rapidly deteriorating land. Unfortunately, however, they failed to record the provenience and context of these remains. The collection was stored for more than 50 years, until the spring of 2019 when work on this thesis began. An archaeological team from the University of Missouri conducted a site assessment in 1982, over a decade after the excavation by

UTK. They were called to the site in response to an additional exposure of remains from a sinkhole but did not perform any exhumations (Horn). The corresponding report written by Horn makes no mention of the earlier excavations in the 1960s but does assign a site number: 23SL452.

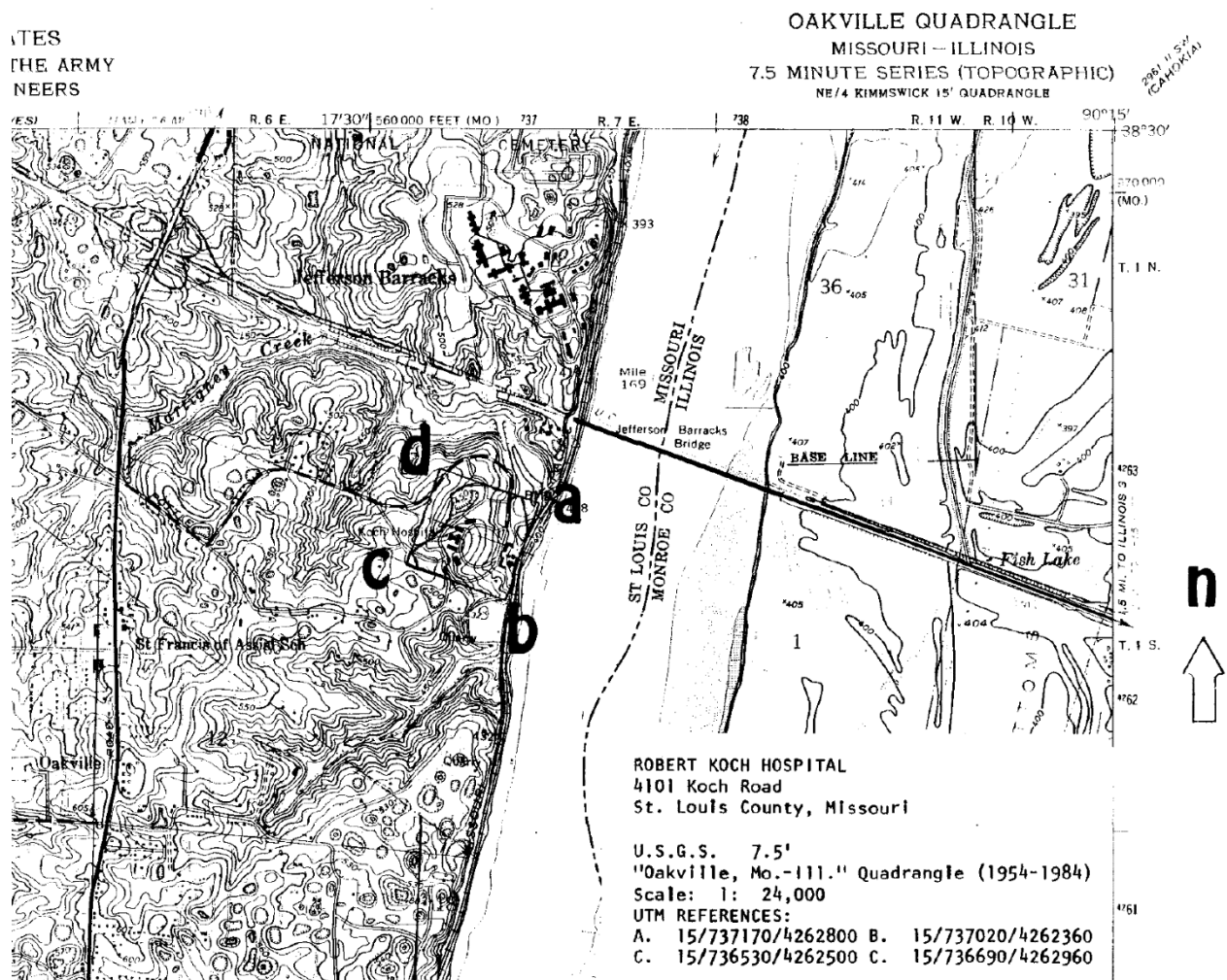


Figure 1: Topographic map of the Koch land and the surrounding area (Bass and Eberle 1984)

In addition to the absence of archaeological records from the 1960s partial exhumation, there are no patient records and very few death records from the Quarantine Station and Koch Hospital. In the 1880s, a fire destroyed all burial records dating back to the opening of the site (Bass and Eberle 1984). These records would have included not only the burials of the dead from Quarantine Station, but also those who were reburied from other city-owned hospitals and cemeteries that were overflowing (Bass and Eberle 1984). The sink holes at Koch functioned as

pre-dug mass burial pits into which human remains could conveniently be placed. We have no records of the dead or their graves. The locations of the graves on the property are unknown; furthermore, these burials have likely shifted from their *in-situ* locations. There are no gravestones marking individual or mass graves. Without patient lists or death records, these remains recovered by UTK are part of an effectively open population of the millions who died during the repeated epidemics.

The individuals buried at Koch Cemetery were almost entirely of low socioeconomic status. Many were immigrants or the children of immigrants who were pushed to the margins of society. Poor hygiene and overcrowded living arrangements led to repeated epidemics of cholera, leprosy, yellow-fever, typhoid fever, diphtheria, and smallpox that plagued St. Louis for much of the 19th and early 20th centuries. The mass quarantine of marginalized individuals effectively stripped away their identities as they were sent to Koch Hospital to die, especially in epidemic years. The individuals represented in this study are a very small portion of those who died and were buried on this land. The others buried at the site are almost entirely unknown. For individuals who are attempting to trace their ancestry back to St. Louis – especially those with ancestors who immigrated to the area during this time – Koch Cemetery leaves many questions unanswered. It is unclear how many decedents are still buried at Koch Cemetery, just as it is unclear where they were buried and from what disease they died. The disregard for the dead evident in this case violates their dignity and renders these already marginalized individuals further dehumanized in death.

The goals of this thesis are to determine how many individuals are present amongst the fragments recovered by UTK, and to establish contextual information for the site itself. In pursuit of these goals, this thesis will also assess modern methods for decommingling and analysis of

highly fragmentary remains in an open population with very little contextual information. The focus of archival research was to analyze the socioeconomic dynamics of health during epidemics.

Original Site History Summarized from Bass and Eberle (1984)

In 1984, two members of the St. Louis County Parks and Recreation Department wrote a report on Koch Hospital in an attempt to have the buildings preserved as part of the National Register of Historic Places. The report includes a brief history of the land and several images of the buildings at Koch as they stood in 1984. This history and some of the images are included below.

In 1854, the city of St. Louis purchased a 50-acre plot of land 15 miles south of the city center for use as a quarantine station for cholera, leprosy, yellow-fever, typhoid fever, diphtheria and smallpox. The first recorded set of interments made on the land was a reburial from the Benton Party City Cemetery. After the epidemics of the 1850s declined, the city considered selling the land, but an outbreak of yellow fever in 1878 demonstrated the need for the city to control highly contagious diseases. These diseases disproportionately affected the poor, densely populated areas of St. Louis, where living conditions accelerated the spread of disease. By the end of the nineteenth century, approximately 18,000 people had been buried on the land. Unfortunately, in the late 1880s, all burial records for those interred on the land were destroyed in a fire.

The first building on the land, constructed in 1907 (**Figure 2**), was an administration building meant for smallpox quarantine. However, before construction was completed, smallpox was effectively eliminated, leaving the hospital building unused. In 1910, it was repurposed by Dr. John C. Morfit, hospital commissioner, to be used as a tubercular quarantine. This transition also involved changing the name of the hospital from the Quarantine Smallpox Hospital to the Koch

Hospital named after Robert Koch who discovered the mycobacterium tuberculosis bacillus. Bass and Eberle include a map of the hospital structures as they stood in 1984 (**Figure 3**). The only structure that predates the administration building is the water tower, constructed around 1879 (**Figure 4**).



Figure 2: The first building built on the Koch property in 1907 was meant to be an administration building for the Quarantine Smallpox Hospital. Pictured as it stood in 1984 (Bass and Eberle 1984)

After 1910, the high rates of death caused by TB – one in ten deaths per year – forced the hospital to expand its infirmary in 1922, 1924, 1936, and 1939. In 1928, the hospital had a space for 240 patients, but was overfilled with 420, with another 100 on the waiting list. The demand for care remained high throughout the hospital's history. The situation was also complicated in 1942 when World War II created a shortage of available doctors and nurses. After the war, improvements in sanitation and hygiene left the quarantine hospital with very few patients to serve. By the 1950s, the hospital had become a nursing home, and remained so until 1983 when the last patients were transferred to other hospitals.

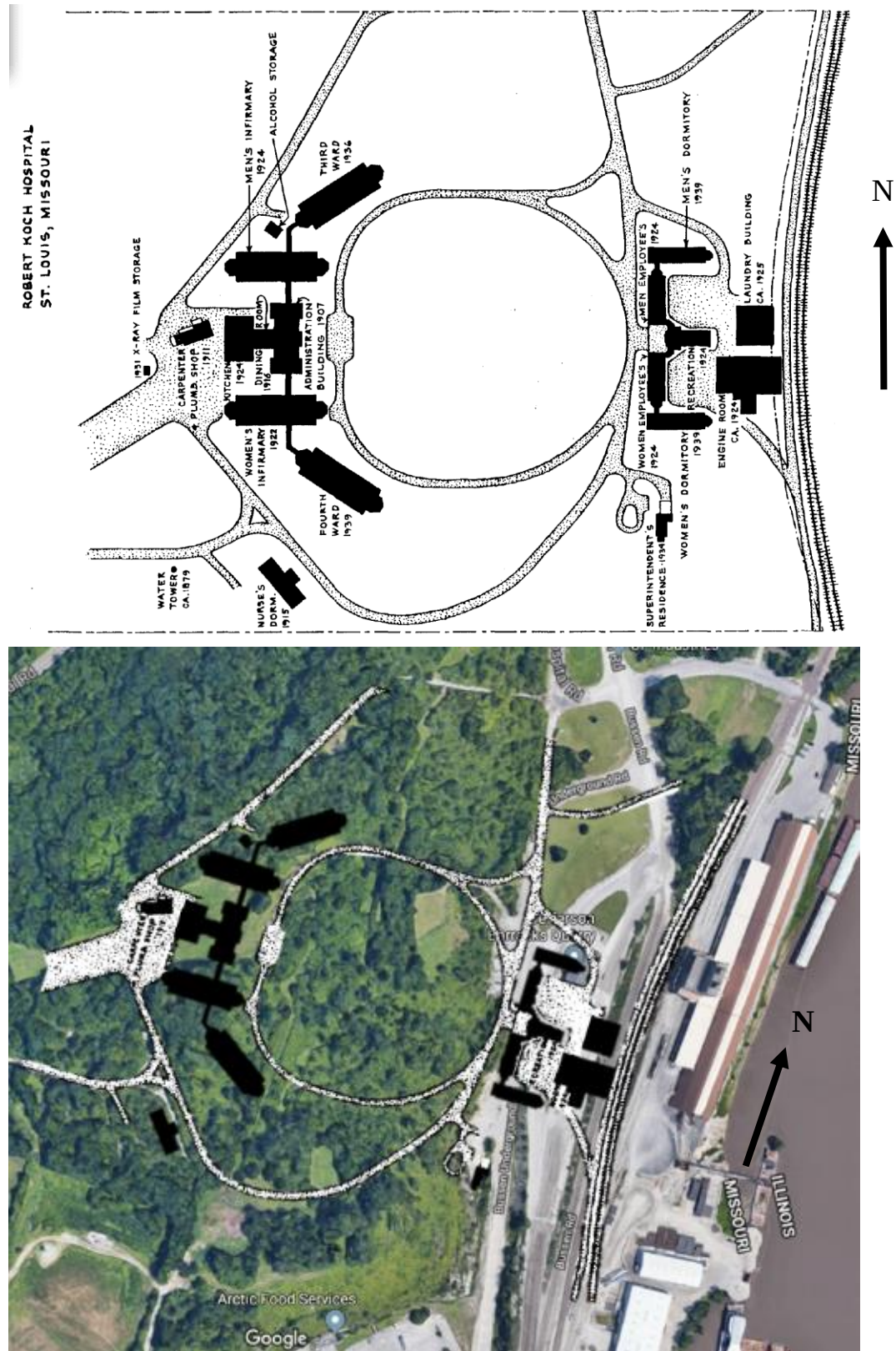


Figure 3: a. top image, map drawn by Baer for use in the 1984 report by Bass and Eberle; b. bottom image, Baer's map superimposed on modern land which is unoccupied and devoid of buildings.



Figure 4: The water tower on the Koch Property, which was likely constructed in 1879 when the land was still being used as Quarantine Station.

Osteological Methods

Estimating the Number of Individuals Present

Because of the highly fragmentary and commingled nature of the remains, and the poor recovery rate relative to the 18,000 individuals known to be buried on the land, it is difficult to calculate how many individuals are represented in this sample. I utilized bioarchaeological and zooarchaeological methodologies to estimate the number of individuals in the original death assemblage now represented in the six boxes.

There are three general methods suggested for this estimation, including Minimum Number of Individuals (MNI) or Minimum Number of Elements (MNE), the Lincoln Index (LI), and the Most Likely Number of Individuals (MLNI). MNI is the most popular method for analysis and yields the minimum number of individuals needed to contribute to the given sample. This method uses the most frequently represented element and assumes that all elements that appear less frequently must have come from the same set of individuals. For collections with high recovery rates and limited fragmentation, MNI is useful and can be determined by the maximum number of the left or right side of the most represented element (Adams and Konigsberg 2008, Mack et al. 2015). Because MNI is heavily reliant on recovery rates, a scenario with limited or partial recovery will result in a MNI that underestimates the original population (Adams and Konigsberg 2004, Adams and Konigsberg 2008).

LI is the basis for the MLNI. LI is a zooarchaeological method used to estimate the size of the living population represented by the death assemblage, independent of the recovery rate and taphonomic conditions (Adams and Konigsberg 2004, Adams and Konigsberg 2008). One caveat, however, is that LI requires that sample bias is random. Different from MNI, LI requires pair-matching left and right elements to each other to ensure that the same individual is not being

counted twice. Matching is necessary because the total number of left and right elements are used in calculations. MLNI also requires pair-matching but is calculated to remove bias created by taphonomy, fragmentation, disarticulation, and other means of commingling.

Because the latter two methods of estimation depend on pair-matching, they can be difficult in highly fragmentary and commingled collections, but their results are generally far more accurate than those of MNI for limited recovery rates. The Confidence Interval calculation suggested by Adams and Konigsberg (2008) was used to assess the precision of the estimates based on the data.

Zonation and Landmark Systems

Several different methods of inventory were employed, including the zonation system, landmark system, pair-matching, and osteometric sorting. The zonation system was introduced by zooarchaeologist Richard Morlan (1994) in a study involving bison bone, wherein he suggested defining zones on a bone to help assess the percent completeness of the remains by comparing the number of expected zones to the number of zones present in each element. Knusel and Outram (2004) repurposed Morlan's methods for use in human skeletal remains, suggesting zones for each element to be recorded individually as either present or absent (**Figure 5a**). A further development of the zonation method was the introduction of the landmark system, which designated well-known landmarks on a bone, scoring them either zero or one (i.e., present or absent, respectively) (Lambacher et al. 2016, Mack et al. 2016). The landmarks are distributed along and across the surface of the bone so that the entirety of the element is represented by the system (**Figure 5b**). Modifications have been made to the methods of Knusel and Outram (2004) and Mack et al. (2016) due to differences in preservation, element presence in the sample and which landmarks were most useful for element identification. Detailed illustrations of the zone and landmark designations can

be found in Appendix A. This is particularly useful in highly fragmentary remains as fragments often contain recognizable landmarks while the broader zones may be absent (Lambacher et al. 2016, Mack et al. 2016).

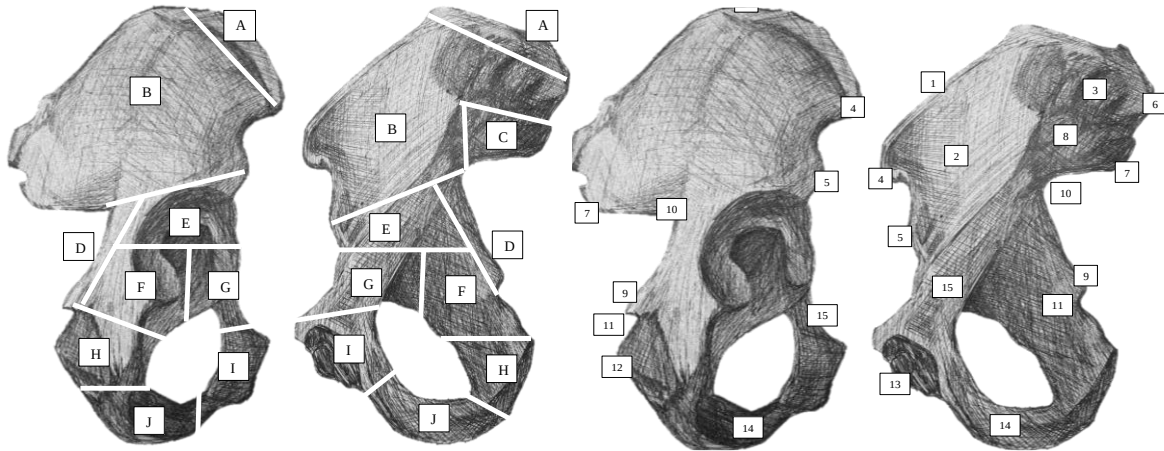


Figure 5: a. left image, drawing by author displaying the application of the zonation method (modified from Knusel and Outram 2004); b. right image, drawing by author displaying the application of the landmark method (modified from Mack et al. 2016)

Other considerations with these estimates include the rate of recovery and degree of fragmentation. The Bone Representation Index (BRI) is calculated through comparison of the expected number of a particular bone (based on death assemblage estimates) and the observed number of that bone in the sample (Lambacher et al. 2016, Brown 2019). BRI helps with estimations of the recovery rate for the sample as it compares the number of individuals who were likely present at death with the number that exist in the current sample.

Pair-Matching

Part of the process of both reassociation of individuals and death assemblage estimation is pair-matching elements or matching the right and left element from an individual. Two methods are used for this: visual matching based on morphology, and osteometric matching based on general size and shape of elements. Both methods of pair-matching are typically limited to the

appendicular long bones (except the clavicle). While on average visual and osteometric pair-matching are equally effective, osteometric sorting is less dependent on experience and the condition of the remains (LeGarde 2019).

Visual pair-matching is conducted through macroscopic morphological analysis. Elements are initially sorted by overall size and robusticity before closer analysis of morphological features (LeGarde 2019). Potential matches are recorded for later comparison with osteometric methods. Osteometric pair-matching involves statistical analyses to determine if there are enough similarities to not rule two bones out as a matching pair (Thomas et al. 2013). Measurements are taken from each element based on an established set of points derived from multiple databases of osteometric measurements compiled by Moore-Jansen et al. (1994). Every element is measured based on the compiled database. The amount of difference between each set of bones is compared to the standard deviations of the reference data using a p -value from a t distribution, comparing the data to a null hypothesis of zero difference between the bones. A p -value is calculated using the t -distribution to evaluate the strength of the association. Byrd (2008) recommends a p -value threshold of 0.10.

While methods of osteometric sorting cannot be used to definitively establish matches, their strength is excluding pairings through a process of elimination (Byrd 2008, Schaefer 2008). Lynch (2018) has proposed that multiple breadth measurements can be used in the absence of full measurements because length measurements are relatively more difficult to obtain in highly fragmented samples. A limitation of this multiple breadth measurements, however, is that its ability to exclude individuals is reduced.

Reassociation of Elements

Osteometric measurements can also be used to reassociate elements based on joint articulation and regression modelling of the relationship between different bones in the body. For joint articulations, the differences in breadth of the articular surfaces of articulating elements is analyzed in terms of the data compiled from the reference collections of known articulations (Byrd 2008). Individual measurements will be made for each articular surface of contributing bones, which will then be compared to mean and standard deviation parameter estimates of the reference sample. Byrd (2008) also recommends a two-tailed t-distribution test with a degree of freedom equal to one less than the number of elements in the reference sample to determine the fit of the two elements to each other with a p -value cut-off of 0.05.

Similar to both joint articulation and pair-matching, osteometric reassociation uses both size and shape measurements to determine whether two or more elements or fragments of elements potentially belong to the same individual by excluding those elements that are less likely to belong to the same individual. Depending on which elements are being reassociated, the appropriate regression model based on sample data will be applied (Byrd 2008). According to Byrd (2008) and Lynch (2018), measurements of breadth and girth are comparable to length measurements in their ability to determine if two bones could potentially belong to the same individual. Length, breadth, and girth measurements can be taken from two elements and compared through regression models. t -values compare predicted dependent variables that are output by the regression model to the measurements of the elements in this collection. A p -value is calculated from a two-tailed t -distribution test with a degree of freedom equal to one less than the number of elements in the reference sample. Low p -values reject the association between the elements being tested.

The Bioarchaeology of Epidemics

In the modern era of emerging and reemerging infectious diseases, many bioarcheologists investigate historical and archaeological evidence of epidemics. Throughout pre-antibiotic human history, waves of epidemics have caused abnormally high mortality rates, and in each instance, the catastrophic number of dead forced affected communities to adapt their burial rituals and methods. Under the shadow of morbid pathogens, normal mortuary practices become unsustainable. Physical deaths are compounded by the emotional and spiritual turmoil of the living who are unable to mourn for their loved ones in congruence with their customs. Departure from normal mortuary practices not only has bioarchaeological implications, but also creates significant cultural change.

Cultural Response to Epidemics: Burial Practices

The deep significance of burial rites is evident in the strict adherence to these practices in normal circumstances. These practices are not abandoned unless something so drastic occurs that they simply cannot be maintained (Beauchamp 2012, Hutchinson 2013, Kilonzo and Hogan 1999). Communities who are forced to abandon their traditional rituals are unable to fully mourn their dead with the spiritually and bodily integrity that would normally be expected (Kilonzo and Hogan 1999). The social benefits of proper burial must be weighed against the need to quickly and safely remove human remains from amongst the living. The treatment of the dead reflects the intensity of the crisis and the ability of the living to respond (Signoli et al. 2002). Emergency internments of the dead may be considered as a new form of a burial ritual (Beauchamp 2012). Infectious disease is not isolated to an individual – by its nature infectious disease is a communal concern (Larsen 2018). Thus, our interpretations of historical infectious disease must be within population-

specific contexts. To capture this context, bioarchaeologists must use archival information, which captured the response of the community as it suffered the epidemic (Signoli et al. 2002). Previous research has shown, through both archaeological and historical information, that each community responded uniquely to the high death rates caused by infectious disease.

Throughout Europe there is variation in Black Plague assemblages despite similar religious and cultural treatments of the dead during non-plague times. In most cases, even those outside of Europe, multiple, simultaneous burials were made to contain the dead (Tran et al. 2011, Hutchinson 2013, DeWitte 2016, Gowland and Chamberlain 2005), but the care and methods used in the creation of these graves differed immensely.

The response of England's authorities to the high death rates were generally well-planned and maintained the dignity of the dead to the highest degree possible given the circumstances. A majority of the bioarchaeological research on burial practices during the Black Plague have come from London, which serves as a pristine example of historical urban responses to epidemics. In order to avoid public decomposition on city streets, the strict divides of socioeconomic status, sex, and age that normally determined burial locations and practices were abandoned (Margerison and Knusel 2002). Despite the pressures of racing against decomposition and the sheer numbers of the dead, most London cemeteries maintained order in their burials. The York Mint cemeteries were created specifically for the burial of plague victims. In these cemeteries, even in places where the dead were stacked five feet deep, bodies were carefully arranged and laid to rest one by



Figure 6: Orderly burials at the York Mint Site in London, England; originally from Gowland and Chamberlain 2005

one with layers of dirt separating layers of remains (**Figure 6**, Margerison and Knusel 2002, Beauchamp 2012, DeWitte 2016). To save space, infants were often buried in gaps between adults (Beauchamp 2012). When non-plague cemeteries were forced to inter plague victims, these new burials were often more chaotic, frequently overlapping previous burials causing fragmentation and commingling (Castex 2008). In these cases, attempting to compensate for plague victims in established cemeteries was deleterious to the remains of both the newly dead and those who had been laid to rest years before.

Other cities throughout Europe buried their dead in a rushed and irrational manner, sharply contrasting the careful and respectful internments at London's York Mint cemeteries. Venice, Italy suffered multiple resurgences of the Black Death. Tran et al. (2011) analyzed 92 mass burials from Venice, many of which were overlapping due to poor record keeping on the location of previous trenches. In both Provence, France and Venice, bodies were entangled in random orientations – twisted, face down, etc. – with severe taphonomic damage (**Figure 7**, Signoli et al. 2002, Castex 2008, DeWitte 2016). These body positions suggest that the dead were thrown into their graves from the surface, with circumstances that were too overwhelming to allow



Figure 7: Photographs of the chaotic nature of plague burials in Venice, Italy; originally from Tran et al. 2011

the dignity of individual, carefully lain burials. Venice and Provence's irregular and poorly planned burials demonstrate the state of emergency and panic that must have overtaken these cities during historic epidemics.

In the modern epidemics of the 19th and 20th centuries, the individuals who were most vulnerable to disease were individuals of low socioeconomic status and racial/ethnic minorities. The indiscriminate nature of pre-antibiotic epidemics no longer applied to American cities with wide disparities in access to medical resources along socioeconomic and racial/ethnic lines. The social dynamics of a population therefore define that population's health; especially in cases of infectious disease, which operates on a communal rather than individual scale (Zuckerman and Crandal 2019, Larsen 2018, Hutchinson 2013). Transmission is increased by poor living conditions, malnutrition, and environmental risks that often affect communities of low socioeconomic status, particularly those composed of racial and ethnic minorities (Larsen 2018). The disparities between the health and survival rates of white Americans and racial/ethnic minorities during the 19th and 20th century were more drastic than it is today, but these same societal structures still persist and negatively affect the health of people of color. Poverty caused by historically implemented structures of segregation and discrimination still denies minority populations access to quality healthcare (Zuckerman and Crandal 2019).

Osteological Evidence of Epidemics

Amongst the skeletal remains of plague victims, few individuals will exhibit skeletal lesions associated with the infectious disease that killed them (Beauchamp 2012, Margerison and Knusel 2002, Hutchinson 2013, Castex 2008, Larsen 2018). Across studies of European epidemics, bioarchaeologists have identified epidemic burials as multiple, simultaneous burials with the

absence of disease-specific lesions and trauma – which could be associated with more violent causes of catastrophic deaths such as war, massacre, and natural disasters (Castex 2008). Careful assessment of the condition of remains and the demographics of the burial allow bioarcheologists to distinguish between the various causes of mass burials. One defining factor of epidemic-caused deaths is that the responsible infectious diseases are often so virulent and so morbid that they kill affected individuals too quickly to leave any pathognomonic skeletal lesions (Beauchamp 2012, Margerison and Knusel 2002, Hutchinson 2013, Castex 2008, Larsen 2018). This concept has been widely discussed amongst bioarchaeologists since the publication of Wood et al.'s 1992 publication of the Osteological Paradox, which established that a lack of skeletal pathology in an assemblage is just as likely to be caused by high rates of death from infectious disease as they were to be caused by population level improvements of health. Many papers that discuss the osteology of epidemics fail to consider these limitations of paleopathology, equating a lack of lesions with evidence against disease. Additionally, we cannot expect to perfectly capture the health of a living population from the remains of their dead, as we are unable to determine culturally specific definitions of health or discover soft tissue pathologies that did not affect the bone (Larsen 2018, Waldron 2001). Some infectious diseases such as TB, which often became a chronic condition, may be detectable in bone, but this depends on the individual manifestations of the disease. In a majority of cases where mass casualties are caused by infectious disease, the pathogen will act too quickly to leave osteological evidence.

Demographics of the Dead

Because of the absence of osteological evidence of disease in epidemic death assemblages, bioarchaeologists have turned to studying the paleodemographic makeup of these mass burials to ascertain distinctions between various causes of catastrophic assemblages and their attritional

counterparts. Attritional assemblages are those composed during normal circumstances with relatively steady death rates while catastrophic assemblages are made during periods of high death rates that outstrip the resources of communities to bury their dead (Beauchamp 2012). The high number of deaths of infants and the elderly with low death rates in older children and young adults characterize normal assemblages, and these patterns are highly preserved across populations (Gowland and Chamberlain 2005). Knowledge of attritional patterns throughout time allows bioarchaeologists and paleoepidemiologists to identify statistical deviations from normal conditions.

While we cannot reconstruct the demographics of a living population from the demographics of the dead, the distribution of victims by sex and age can allow us to distinguish various causes of catastrophic and attritional assemblages (Waldron 2001, Larsen 2018, Margerison and Knusel 2002, Castex 2008). Because of differential frailty (age-specific likelihood of death), each age group in a population will be susceptible to certain catastrophic events than others. In cases of war, the death assemblage is most likely to be composed of young adult males with widespread skeletal trauma (Margerison and Knusel 2002). In famine, the most vulnerable individuals – namely the elderly and very young – will be the first to perish, which would mimic attritional death assemblages, but burials would occur at a higher frequency (Margerison and Knusel 2002). Natural disasters may mimic infectious disease by acting indiscriminately across demographic groups, but victims are more likely to present with skeletal trauma.

The indiscriminate nature of pre-antibiotic infectious diseases creates unique demographic profiles of the dead. For instance, across all three versions of the plague, every demographic group was affected equally in both virulence and morbidity (Gowland and Chamberlain 2005, Margerison and Knusel 2002). A key feature of the paleodemographics of epidemic mass burials

is the overrepresentation of adolescents, young adults, and adults who normally have lower frailty than infants and the elderly (Margerison and Knusel 2002, Castex 2002, Fuchs et al. 2019). This spike in morbidity amongst young adults is primarily driven by increased deaths in females, but both sexes experience higher mortality at a younger age (Margerison and Knusel 2002, Castex 2008). The paleoepidemiological and osteological data from mass burials must be compared to archival and historical data when it is available, which would allow for some correction of archaeological biases caused by differential preservation and sampling. Additionally, these statistical analyses may allow us to address the uncertainty in analyzing archaeological samples within the frame established by the Osteological Paradox.

Social Dynamics of Health, Sickness, and Death

When human populations began to grow and gather in permanent, densely populated regions, infectious disease quickly became the leading cause of death. For much of the 20th century, modern medical treatment lessened the impact of infectious disease, with deaths due to chronic illness becoming most frequent. In recent years however, emerging and reemerging infectious diseases have begun to affect populations on a large scale, most notably the COVID-19 pandemic. The responses of various nations to this crisis have revealed weaknesses in healthcare systems to address the needs of all subpopulations. Communities who cannot protect themselves from infection due to preexisting social structures are often blamed for their illness and subjected to racialized discrimination (Chowkwanyun and Reed 2020). In the United States, COVID has highlighted the wide disparities in healthcare within our population across lines of race and sex. These disparities have deep historical roots and were more evident during the epidemics of the 19th and 20th century. The people on the margins of society are always the most likely to suffer.

Included below is a literature review of research on the health disparities of the 21st century. Because this type of research only began in the past two decades, little is known about the manifestations of social dynamics of health throughout history. We may be better able to understand these dynamics by synthesizing the existing modern issues with historical data, such as those presented in the results section of this thesis.

Sex-Based Disparities in Health and Medical Treatment

Despite progress in sex and gender-based discrimination in the United States in the past century, women still have lower qualities of medical care and worse health outcomes. While most medical literature addressing sex differences refer to biological sex as ‘gender’ and treat ‘gender’ as a binary, researchers highlight the disparities present between male and female sexed patients. Even though modern women go to a primary care physician more often than males, they have increased morbidity and mortality largely due to inadequate diagnosis and treatment of chronic and infectious conditions (Manuel 2018, Kent et al. 2012). Most medical research has focused on the presentation of symptoms and progress of disease in white male patients. 1993 was the first year that medical researchers were mandated to include females and minority groups in their samples despite clear evidence of significant differences in the presentation of symptoms between men and women (Kent et al. 2012). Women’s health issues have historically been reduced to reproductive health problems and moral failings (Kent et al. 2012). Females are less likely to be tested based on their symptoms and less likely to be offered aggressive treatment courses for their conditions. They are 22 times less likely to be offered total joint replacement than males despite a higher prevalence of osteoarthritis in women (Kent et al. 2012). Women are more likely to die than men who present with the same symptoms at the same level of severity (Kent et al. 2012).

Treatments, diagnoses, and health outcomes are all designed to optimize results for white males, disregarding the needs of other demographic groups.

Racial Disparities in Health: Historical and Modern Ramifications

Since the era of imperialism, racism has been deeply rooted in pseudoscience. European colonizers utilized ‘biology’ to rationalize their exploitations of indigenous populations and their resources. Since then, classifications of populations as discrete groups have been defined by imposed social definitions based on eugenic manipulations of biological terminology. As of 2002, a majority of Americans still believed that minorities are less intelligent than white Americans (Institute of Medicine 2002a). This belief was not only held amongst civilians, but among medical personnel who deemed minorities, particularly African Americans as less intelligent, less likely to behave morally, and less likely to follow medical treatment regimens (Institute of Medicine 2002a). These attitudes were established as modern medicine developed throughout Europe and the United States. These racial epithets have been applied to the way that health science researches, diagnoses, and treats medical conditions. The combination of the health ramifications of this legacy with the physical and psychological damage done to minority populations has ensured that racial/ethnic minorities are more likely to be of low socioeconomic status and thus more likely to suffer negative health outcomes with a high burden of both infectious and chronic disease (Chowkwanyun and Reed 2020, Institute of Medicine et al. 2002a and 2002b). Even when studies correct for socioeconomic status and access related limits to healthcare, racial/ethnic minorities received a lower quality of care and were less likely to receive regular medical treatment (Institute of Medicine et al. 2002a, Manuel 2018). These health consequences further hinder the ability of people of color to create social and economic change.

The wide gaps in medical treatment between white Americans and Americans of color have perpetuated the systematic oppression of minorities. Most people of color are aware of the biases in their medical care and are thus less likely to trust the recommendations of their providers as a way to avoid potential abuse (Institute of Medicine 2002a). This fear is not unfounded. Unethical medical experiments have been conducted on African American populations throughout American history and much of modern medical discourse still treats minorities as biologically and anatomically different than white patients (Chowkwanyun and Reed 2020). Chowkwanyun and Reed write:

During tuberculosis outbreaks in the turn-of-the-20th-century urban South, black people as a group were frequently described by public officials as hopelessly ‘incorrigible’ – that is, they disavowed hygienic guidelines and were vice-ridden and therefore were more prone to behaving in ways that make them more likely to contract disease (2020, p 2020).

This rhetoric of blame is often applied to African Americans as exemplified by public treatment of these populations during the COVID-19 and HIV/AIDs pandemics. Within the medical community, physicians often apply these stereotypical and prejudicial biases in their treatment of patients of color. This unequal treatment is partially caused by the heavy imbalance of racial/ethnic diversity in medical professions, which can create cultural and language barriers to care (Institute of Medicine et al. 2002a). This also negatively impacts the ability of people of color to establish positive and consistent relationships with their physicians, which has been shown to be a key component of effective health care (Institute of Medicine 2002a). Medical judgments align with racial/ethnic biases and when physicians are forced to allocate scarce resources, they are less likely to provide care to people of color, effectively deciding that they are less worthy of this care (Institute of Medicine et al. 2002a and 2002b). These decisions are made over and over again by

medical personnel, indicating that this racialized thinking is systematically integrated into the American medical system. Minority populations have lower life expectancies and higher mortality and morbidity (Institute of Medicine 2002b). This clear disparity must be addressed by medical policy and through medical education as it clearly has had dire consequences to the health of minority populations throughout history.

CHAPTER II

MATERIALS AND METHODS

Osteological Materials and Methods

Materials

I received six boxes of human remains from the University of Tennessee's Archaeological Research Lab (ARL) facility. The collection had been stored in cardboard boxes since its recovery from Koch Cemetery, St. Louis, MO in the late 1960s. The remains were of unknown condition. Each box was previously labelled with a number: 780, 781, 782, 783, 784, and 792. Remains were loosely sorted by element into the different boxes, some of which contained labelled paper bags further classifying fragments.

- Box 780 was split into two sections. The larger section contained humeri and the smaller section contained radii.
- Box 781 contained only femora.
- Boxes 782 and 783 both contained cranial fragments, with three dividers creating four sections in each box. Each section contained a large, but fragmentary, portion of the neurocranium and splanchnocranium, surrounded by smaller fragments. In 783, one section contained two of these larger fragments.
- Box 784 contained mostly tibiae, and a few femora.
- Box 792 contained several paper bags, labelled: "Ulna," "Rights," "Innomimates," "Fibulae," and "Tarsals." The "Tarsals" bag contained a smaller bag inside labeled "Metatarsals, Metacarpals, and Phalanges."

All six boxes contained skeletal elements identified or sided incorrectly.

Inventory

I conducted skeletal inventory by assigning an alphanumeric code to each element (**Table 1**) followed by a number to designate the storage bag. This allowed me to create a database that combines osteological inventory with curatorial information. This curatorial information includes the original and new placement of the elements within the box and bag system. Elements within bags containing multiple fragments were catalogued in alphabetical order to refer to specific bones. Side was designated by “-L” for left, “-R” for right, and “-M” for middle (non-paired bones lying along the midline) and “-U” when side could not be determined. For example, FE18B-L translates to FE: femur, 18: bag 18, B: second femur fragment, L: left. Along with the alphanumeric identifier, I recorded a brief qualitative description of the specific element portion (i.e. diaphysis, epiphysis, articular surface, etc.) of each element, along with the original placement of the element within the boxes of the collection.

Table 1: Two-letter designation of elements used in this study.

Element	Letter Code
Cranial Bones	CR
Os Coxae	OS
Sacrum	SA
Humerus	HU
Radius	RA
Ulna	UL
Femur	FE
Tibia	TB
Fibula	FB
Talus	TA
Calcaneus	CA
Tarsals (other than Talus and Calcaneus)	TR
Metatarsals	MT
Foot Phalanges	FP
Carpals	CP
Metacarpals	MC
Hand Phalanges	HP
Fragments	FG

Estimating the Number of Individuals Present

Zonation and Landmark Systems

After inventory, I used the zonation and landmark systems to count each element. In both systems, I recorded landmarks and zones as either a 1 or a 0. A 1 meant that at least 50% of the landmark/zone is present. A 0 meant that the landmark/zone was either absent or less than 50% of it was present. All elements besides the cranium were divided by side. The cranium was not divided by side because it already incorporates siding in landmarks/zones. The zonation system had 16 zones for the cranium, 11 for the femur, 8 for the tibia, 4 for the fibula, 10 for the humerus, 8 for the radius, 6 for the ulna, 19 for the os coxa, 4 for the calcaneus and 4 for the talus. In the landmark system, 82 landmarks were scored for the cranium, 14 for the femur, 9 for the tibia, 6 for the fibula, 15 for the humerus, 7 for the radius, 8 for the ulna, 15 for the os coxa, 5 for the calcaneus, and 4 for the talus. Once counts were finalized, they were totaled for the cranium, and right and left divisions of each element. Diagrams of these zones and landmarks can be found in Appendix A.

Visual and Osteometric Pair-Matching

Visual matches between right and left elements were made by laying fragments out onto the workbench, sorted by side and overall size. Elements that were similar in size were compared by morphology. Taphonomy was not particularly influential as it was homogenous across the sample. Once a match was made, it was recorded for later comparison to osteometric analyses. Osteometric measurements were taken according to the measurements proposed by Moore-Jansen et al. (1994) and compared to data collected by Byrd (2008). Measurements were taken for femora, os coxa, calcanei, fibulae, ulnae, tibiae, radii, and humeri. Because of the highly fragmentary

nature of the remains, most measurements were related to breadth rather than to length. Right elements were compared to their left counterparts using the following equation from Byrd (2008):

$$Difference = \sum |measurements\ of\ bone\ A - measurements\ of\ bone\ B|.$$

Difference values were compared to standard deviations of reference data using a t-distribution. The resulting *p*-values were compared to a cutoff of 0.10.

MNI, LI, and MLNI Calculations

The right and left counts from the zonation and landmark systems were used to calculate MNI, LI, and MLNI. LI and MLNI calculations used the visual pairings that were supported by osteometric pairings. MNI was estimated using the most common element (in this case tibiae). I calculated LI and MLNI using the tibiae so that they could be compared to the MNI estimate. The LI equation is given by Adams and Konigsberg (2008) as:

$$LI = \frac{(number\ of\ left)(number\ of\ right)}{number\ of\ pairs}.$$

The MLNI equation is given by Adams and Konigsberg (2008) as:

$$MLNI = \frac{(L + 1)(R + 1)}{P + 1} - 1.$$

The confidence interval for MLNI was calculated as (Adams and Konigsberg 2008):

$$MLNI\ CI = MLNI \pm 1.96 \sqrt{\frac{(L + 1)(R + 1)(L - P)(R - P)}{(P + 1)^2(P + 2)}}.$$

Bone Representation Index (BRI)

BRI was calculated based on the element counts produced through the landmark method using the following equation from Brown (2019):

$$BRI = \frac{\text{Total elements observed}}{\text{Number of element per individual} \times \text{Estimated number of individuals}}.$$

Joint and Element Reassociation

Osteometric measurements taken during pair-matching were also used for joint and element reassociations based on Moore-Jansen (1994) data points and Byrd (2008) data for reassociation. Joint reassociation required articular breadth data, but only 11 tibiae and 13 femora in the collection had epiphyses intact enough for these measurements. The distal articular breadths of the femora were compared to the proximal articular breadths of the tibiae using the following equation from Byrd (2008):

$$D = |\text{measurement of bone A} - \text{measurement of bone B}|.$$

Difference values were compared to mean and standard deviations from Byrd's 2008 reference sample. A two-tailed t-distribution test was conducted with a degree of freedom equal to one less than the number of elements in the reference sample. This allowed me to determine the fit of the two elements to each other with a *p*-value cut-off of 0.05.

Non-articulating joints were compared for reassociation using regression equations given by Byrd (2008). Radii and humeri could be compared to tibiae. Tibiae, radii, and humeri could be compared to femora. Radii and humeri could be compared to each other. Observed length, breadth, and girth measurements from each element were compared to the predicted values given by the regression equations using the following equation:

$$t = \frac{\hat{y} - y_i}{SE \times \sqrt{1 + \frac{1}{N} + \frac{(x_i - \bar{x})^2}{(N \times S_x^2)}}$$

This t-value was used in a two-tailed t-distribution test with a degree of freedom equal to one less than the number of elements in the reference sample to find a *p*-value. *p*-values below 0.10 were used to reject the association between the elements being tested.

Archival Materials and Methods

The ability to establish contextual information for these particular remains, and create a more complete site history in general, was complicated by a lack of archival data on Koch Cemetery. Therefore, I took a two-pronged approach utilizing news sources as well as ancestry databases. Based on information given by Bass and Eberle (1984), I located several archival sources to search for information about Koch Cemetery. Newspaper clippings from the *St. Louis Post Dispatch* and the *St. Louis Globe* gathered from the *St. Louis Post Dispatch*'s online database were used to better understand and record site history. I attempted to gather primary source information from the site through the *Koch Daily Messenger*, a magazine printed for the residents of the hospital (Bass and Eberle, 1984), but was unable to access this information.

Secondary information about the site was compiled from obituaries and death records from the county and city of St. Louis, accessible through Ancestry Library Edition. Ancestry has information on over 500 individuals who were buried at Koch Tubercular Cemetery. Preliminary searches for "Koch Cemetery" and "Quarantine Cemetery" yielded three databases including the "1600-current, US Find a Grave Index," the "1850-1902 Missouri Death Records" and the "Missouri Death Records 1850-1931." These databases do not encompass the entire site history but offer a good sample size for individuals buried there. I collected the follow information about these individuals: first and last name (and middle initial when it was available), sex, birth year,

death year, country of birth, state if born in the US, and ancestry. Birth and death years were used to calculate age at death. Birthplace was used to infer immigrant status.

CHAPTER III

OSTEOLOGICAL RESULTS

Inventory

The six boxes contained a total of 823 bone fragments, of which 97 were unidentifiable, most from long bone diaphyses degraded by taphonomic effects and with no distinguishing features. Inventory began with sorting by element and side, followed by labeling and reorganizing within boxes for easy access to elements during later analysis. **Table 2** summarizes the number of fragments by element type.

Table 2: Number of fragments by element designation.

Fragment Designation	Letter Code	Number of Fragments
Cranial	CR	266
Vertebral	VT	6
Humerus	HU	57
Radius	RA	52
Ulna	UL	29
Carpals	CP	2
Metacarpals	MC	6
Hand Phalanges	HP	4
Os Coxae	OS	67
Sacrum	SA	2
Femur	FE	66
Tibia	TB	67
Fibula	FB	41
Talus	TA	17
Calcaneus	CA	14
Other Tarsals	TR	6
Metatarsals	MT	22
Foot Phalanges	FP	2
Unknown Fragments	FG	97

Estimating the Number of Individuals Present

Zonation and Landmark System Results

Due to the high degree of fragmentation, landmark and zonation analyses were conducted to count the elements and reduce chances of redundancies. Crania, humeri, radii, femora, and tibiae

had the most recognizable zones and landmarks, and yielded the highest counts. Inventory, landmark and zonation data can be found in Appendix A. These counts (**Table 3**) were used in estimation of the number of individuals in the assemblage.

Table 3: Results of the zonation and landmark systems

Element	Zonation		Landmark	
	Left	Right	Left	Right
CR	16		17	
HU	17	12	16	12
RA	14	12	16	12
UL	11	10	11	11
OS	8	9	9	6
FE	15	10	17	10
TB	16	16	16	17
FB	10	6	9	6
TA	5	10	5	10
CA	5	6	5	6

Visual and Osteometric Pair-Matching

Visual pair-matching was only possible among femora, humeri, and tibiae. These matches were made using primarily size and morphology, as taphonomic staining was uniform across the collection. Epiphyses were the least degraded portions of long bones, and often represented the entire element. Visual pair-matching yielded eight pairs of humeri, six pairs of femora, and six pairs of tibiae. Every element that was visually paired was fragmentary and incomplete.

Osteometric pair matching was only possible with humeri, femora, and tibiae. Humerii were too fragmentary for traditional osteometric sorting, which utilizes complete elements. Because of this, a fragmentary analysis was conducted and recorded alongside visual matching (**Table 4.a**). This analysis did not exclude any potential pairs. Complete femora FE23-R, FE24-R, FE25-R were compared to FE3-L and FE5-L. Combined results of visual and osteometric pair-matching of femora are presented in **Table 4.b**. The match between FE5-L and FE23-R was included in both visual and osteometric pairing. All other visual matches were between elements

that were too fragmentary for this osteometric sorting. Another test of pair-matching was run using fragmentary femora (**Table 4.c**). Osteometric pair-matching of complete tibiae was only possible for TB45-L and TB53-L against TB31-R and TB32-R (**Table 4.d**). The only match that was not excluded was between TB31-R and TB45-L, which was also a visual match. Fragmentary sorting could only exclude one femur from matching with all others. All comparisons used a *p*-value cutoff of 0.10.

Table 4: Key for Pair-Matching.

Pair is Not Excluded	Pair is Excluded	Pair is a Visual Match	Osteometric Comparison Not Possible

Table 4.a: Humeri pair-matching, combined visual and osteometric results.

		Right Humeri												
		HU71-R	HU72-R	HU74-R	HU76-R	HU77-R	HU78-R	HU79-R	HU80-R	HU81-R	HU82-R	HU83-R	HU84-R	HU98-R
Left Humeri	HU73-L													
	HU88-L													
	HU93-L													
	HU94-L													
	HU95-L													
	HU96-L													
	HU97-L													
	HU99-L													
	HU100-L													
	HU101-L													
	HU102-L													
	HU103-L													
	HU104-L													
	HU105-L													
	HU106-L													

Table 4.b: Complete femur pair-matching, combined visual and osteometric results.

		Right Femora							
		FE20-R	FE21-R	FE22-R	FE23-R	FE24-R	FE25-R	FE26-R	FE27-R
Left Femora	FE1-L								
	FE2-L								
	FE3-L								
	FE5-L								
	FE6-L								
	FE8-L								
	FE10/17-L								

Table 4.c: Fragmentary femora pair-matching, combined visual and osteometric results.

		Right Femora							
		FE20-R	FE21-R	FE22-R	FE23-R	FE24-R	FE25-R	FE26-R	FE27-R
Left Femora	FE1-L								
	FE2-L								
	FE3-L								
	FE4-L								
	FE5-L								
	FE6-L								
	FE7-L								
	FE8-L								
	FE10/17-L								
	FE11-L								
	FE12-L								
	FE14-L								

Table 4.d: Complete tibia pair-matching, combined visual and osteometric results.

		Right Tibiae						
		TB30-R	TB31-R	TB32-R	TB33-R	TB34-R	TB35-R	TB68-R
Left Tibiae	TB42-L							
	TB43-L							
	TB44-L							
	TB45-L							
	TB46-L							
	TB47-L							
	TB53-L							
	TB54-L							
	TB58-L							

Number of Individuals Present

MNI, LI, and MLNI were calculated from landmark systems' count of the tibia. The tibia was used because it was the most abundant element in the collection. There were six pairs, 16 left, 17 right tibiae. MNI was estimated at 17 individuals. The LI estimated 45 individuals. MLNI estimated 40 ± 18 individuals, with a 95% confidence interval.

Bone Representation Index (BRI)

To maintain consistency, the tibia was also used to calculate BRI, which is estimated to be 0.4125, meaning that more than half of the tibiae in the original assemblage were not recovered during the late 1960s exhumations.

Joint and Element Reassociation

Overall, osteometric results were limited by the fragmentary condition of remains, which prevented measurements from capturing the morphology of elements. Joint articulations could only be performed between the distal femur and proximal tibia because they were the only articulating elements with suitably preserved epiphyses to obtain the required measurements. A p-value cut off of 0.05 was used. The results of this analysis are presented in **Table 5**. These analyses had more exclusionary power than the pair-matching tests.

Table 5: Key for Joint Reassociation.

Reassociation Not Excluded	Reassociation Excluded

Table 5.a: Joint reassociation results between right distal femora and proximal tibiae.

		Right Femora						
		FE17B-R	FE20-R	FE22-R	FE23-R	FE24-R	FE25-R	FE27-R
Right Tibiae	TB30-R							
	TB31-R							
	TB32-R							
	TB65-R							
	TB70-R							

Table 5.b: Joint reassociation results between left distal femora and proximal tibiae.

		Left Femora					
		FE3-L	FE4-L	FE5-L	FE6-L	FE7-L	FE8-L
Left Tibiae	TB43-L						
	TB44-L						
	TB45-L						
	TB46-L						
	TB47-L						
	TB53-L						

Osteometric reassociation of non-articulating elements was conducted in the following combinations: radius and tibia; humerus and tibia; tibia and femur; radius and femur; humerus and femur; and radius and humerus. p-values below 0.05 signified that the elements were not from the same individual. All results are included in **Table 6**.

Table 6: Key for Element Reassociation

Reassociation Not Excluded	Reassociation Excluded

Table 6.a: Element reassociations between tibiae and radii. All matches excluded.

		Tibiae		
		TB31	TB32	TB45
Radii	RA131			
	RA140			

Table 6.b: Element reassociation between tibiae and humeri.

		Tibiae		
		TB31	TB32	TB45
Humerus	HU82			

Table 6.c: Element reassociation between femora and tibiae.

		Femora				
		FE3	FE5	FE23	FE24	FE25
Tibiae	TB31					
	TB32					
	TB45					

Table 6.d: Element reassociation between radii and femora.

		Femora				
		FE3	FE5	FE23	FE24	FE25
Radii	RA131					
	RA140					

Table 6.e: Element reassociation between humeri and femora.

		Femora				
		FE3	FE5	FE23	FE24	FE25
Humerus	HU82					

Table 6.f: Element reassociations between radii and humeri.

		Humerus
		HU82
Radii	RA131	
	RA140	

CHAPTER IV

ARCHIVAL RESULTS

Demographic Results from Ancestry LE and Newspapers.com

The Ancestry LE Database provided information for 532 individuals buried between 1862 and 1929, and a September 9, 1878 *St. Louis Globe-Democrat* publication (Quarantine 1878) included data for an additional 18 individuals. The demographic information for all 550 individuals was input into Excel. Descriptive statistics showed 393 males (71.5%), 119 females (21.6%), and 38 (6.9%) individuals of unknown sex (**Figure 8**). A majority of individuals were white (324, 59%), 160 individuals were of unknown ancestry (29%), 65 individuals were black (12%), and one individual was Native American (0%) (**Figure 9**).

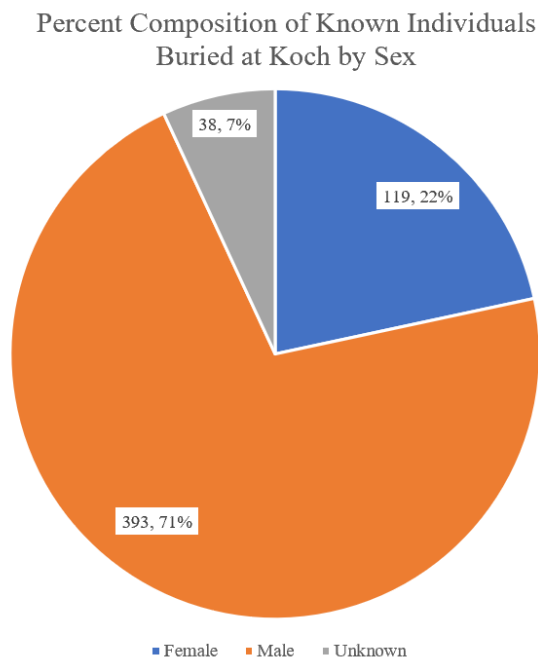


Figure 8: Percent Composition of Known Individuals Buried at Koch Cemetery by Sex. There are 393 males (71%), 119 females (21.6%), and 38 (6.9%) unknown.

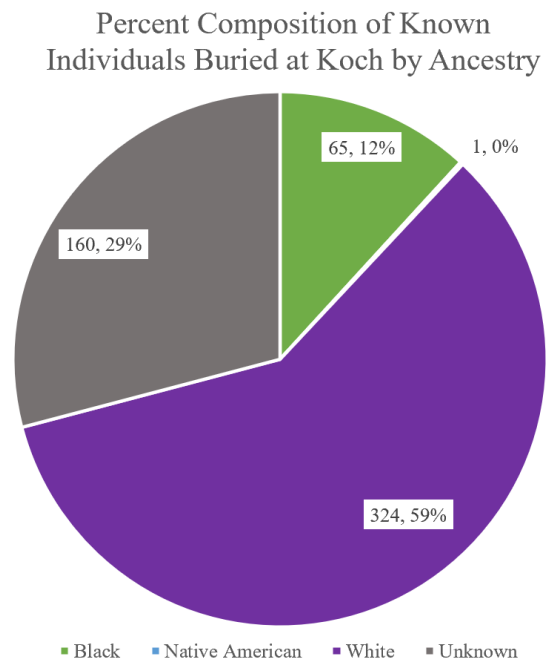


Figure 9: Percent Composition of Known Individuals Buried at Koch Cemetery by Ancestry. There are 324 white individuals (59%), 160 individuals of unknown ancestry (29%), 65 black individuals (12%), and one Native American individual (0%).

A majority of the 291 individuals with a country of origin listed were immigrants. The other 261 individuals did not have a known country of origin. Only 83 individuals (15%) in the sample were from North America, specifically Canada and the United States. More than 20% (120 individuals) were from Northern Europe, specifically England, Ireland, Norway, Scotland, and Sweden, while 83 individuals (15%) were from Western Europe, specifically Austria, Bohemia, France, Germany, Hanover, Holland, and Switzerland. Three individuals were from Italy (coded as Southern Europe), one was from Poland (coded as Eastern Europe), and one was from Jamaica. Including individuals from Canada, the total number of known immigrants was 214, (39%). This information is summarized in **Figure 10**.

Percent Composition of Known Individuals Buried at Koch by Country of Origin

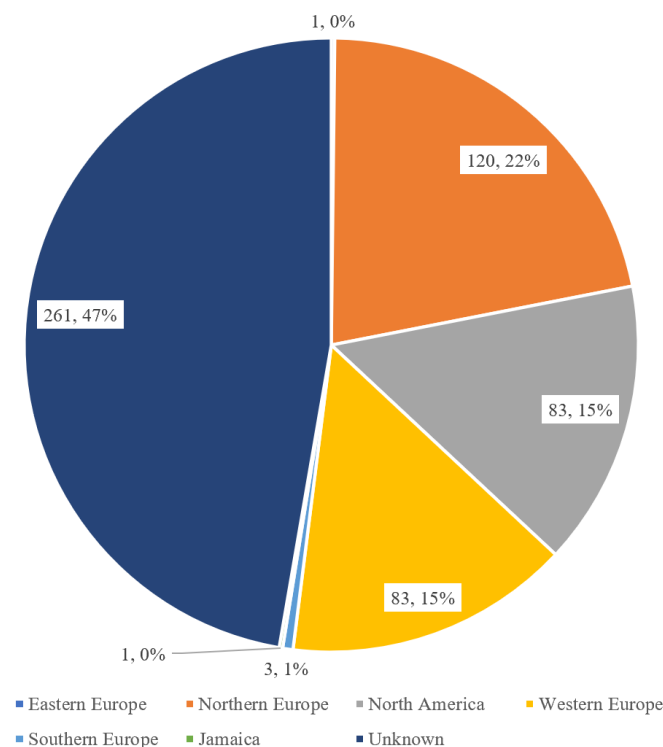


Figure 10: Percent Composition of Known Individuals Buried at Koch Cemetery by Country of Origin. 261 individuals' countries of origin are unknown (47%), 120 individuals are from Northern Europe (22%), 83 individuals are from North America (15%), 83 individuals are from Western Europe (15%), three are from Southern Europe (1%), one is from Eastern Europe (0%), and one is from Jamaica (0%).

Age at death was analyzed by sex, ancestry, and immigrant status. In all cases, there were significant disparities. When comparing distributions of males and females, females died 7.42 years younger than males ($p = 0.0002$) (**Figure 11**). The oldest male in the sample was 93 years old, and the oldest female was 79. Black individuals died 10.88 years younger than white individuals ($p = 0.0005$) (**Figure 12**). Interestingly, immigrants died 8.43 years older than US born individuals ($p = 0.0021$) (**Figure 13**).

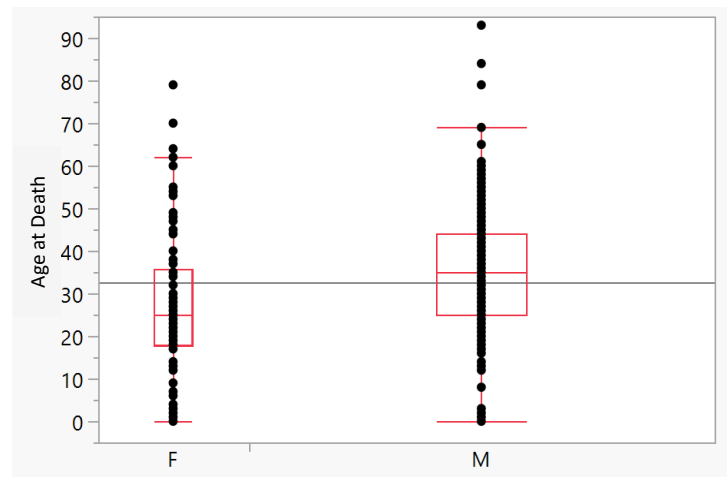


Figure 11: Boxplots of Age at Death Distributions by Sex. Females died 7.42 years younger than males ($p = 0.0002$). Females had a median Age at Death of 25 with an interquartile range (IQR) of 18, while males had a median Age at Death of 35 with an IQR of 19.

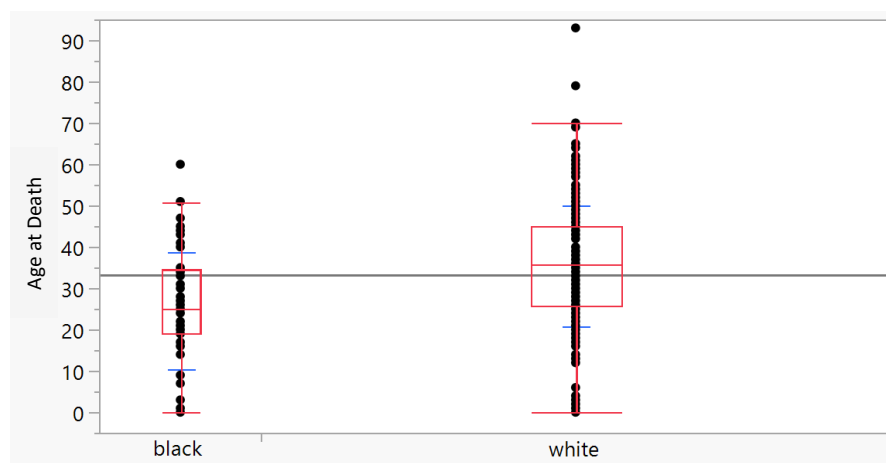


Figure 12: Boxplots of Age Death Distributions by Ancestry. Black individuals died 10.88 years younger than white individuals ($p = 0.0005$). Black individuals had a median Age at Death of 25 with an IQR of 15.75, while males had a median Age at Death of 36 with an IQR of 19.

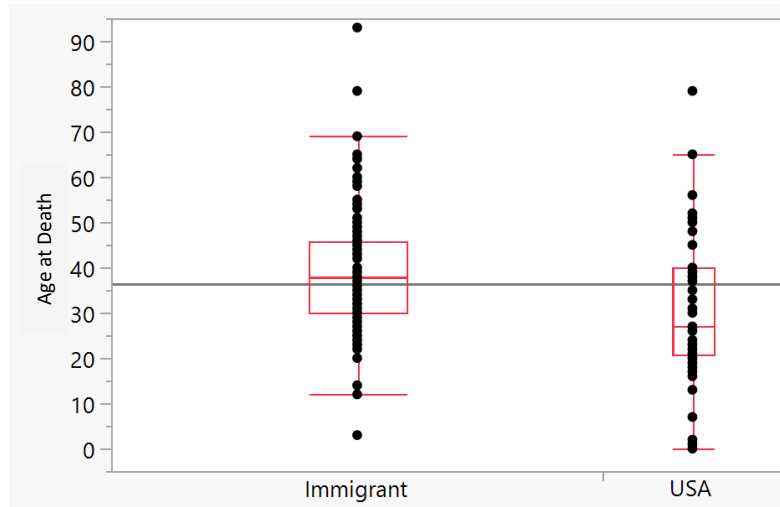


Figure 13: Boxplots of Age at Death Distributions by Immigrant Status. Immigrants died 8.43 years older than individuals born in the United States ($p = 0.0021$). Immigrants had a median Age at Death of 38 with an IQR of 16. United States born individuals had a median Age at Death of 27 with an IQR of 19.25.

Newspapers.com Historical Results

The Grounds at Koch

The Koch Cemetery land was chosen by the city for use as a Quarantine Station because it allowed for the easy unloading of and occupation by potentially infectious people coming to St. Louis via the Mississippi (Yellow Fever 1879, Sutton 1983). The sick were taken off their ships upon inspection by city officials before being transferred to steam ships which carried them to Quarantine (Koch Hospital on Guard 1937). It was previously believed that the only structures at Koch during the Quarantine Station phase were simple frame wooden buildings that were torn down as soon as patients no longer needed them. However, a story in *At Quarantine* (1894) described more permanent structures. The earliest description of Quarantine Station was written in 1894 when a reporter and artist visited the site to interview Dr. Joseph Hardy (**Figure 14**), the physician in charge. The writer notes the presence of a brand-new brick administration building (**Figure 15a**) and that Dr. Hardy had a permanent residence on the premises (**Figure 15b**).



Figure 14: Portrait of Dr. Joseph Hardy included in the At Quarantine Article (1894). Inscription reads “*Dr. Joseph Hardy.*”

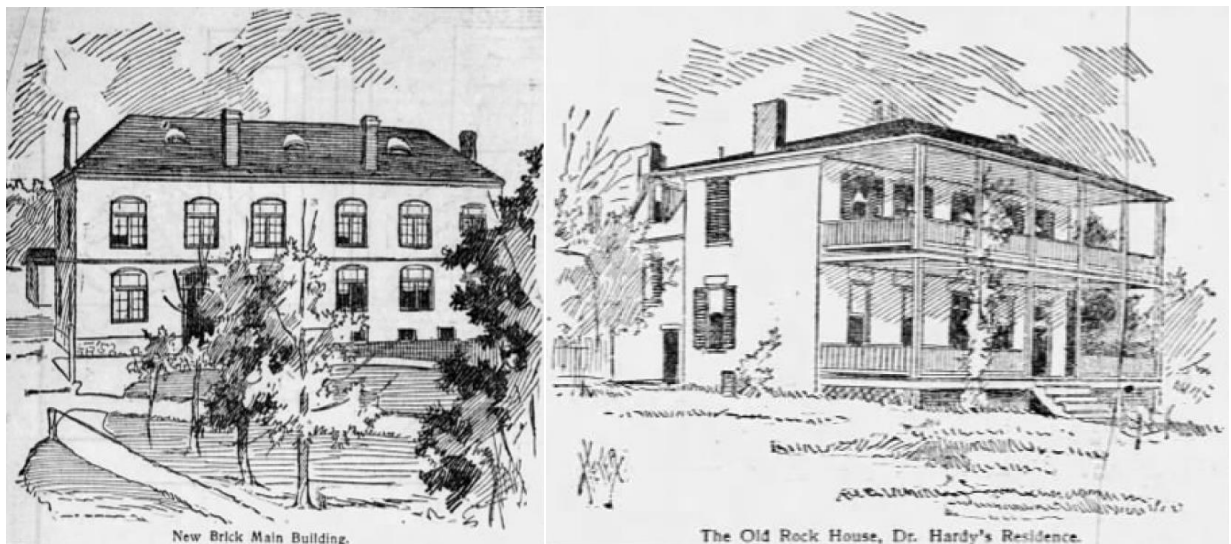


Figure 15: a. left, sketch of brick structure, inscription reads “*New Brick Main Building;*” b. right, sketch of Dr. Hardy’s house, inscription reads “*The Old Rock House, Dr. Hardy’s Residence*” (At Quarantine 1894).

Beyond the descriptions of these structures, specific attention was paid to the cemetery:

“That is one of the sink holes this country is honeycombed with’ said [Dr. Hardy] ‘in that ... hundreds of cholera victims were buried in any way that suggested itself; no coffins, no care, no record to show who they were, there was no time for that” (At Quarantine 1894).

The doctor notes that the hole had shifted multiple times since the earlier burials, and that because of this shifting, the hospital workers had been sent down “to cover up with dirt the bones of those who were ‘dumped’ simply dumped, into [the] sinkhole nearly thirty years [earlier]” (At Quarantine 1894). The author included a drawing of the cemetery (**Figure 17**) with the lone inscribed gravestone memorializing the 56th USC Infantry, which was buried collectively with no record of individual names (At Quarantine 1894).

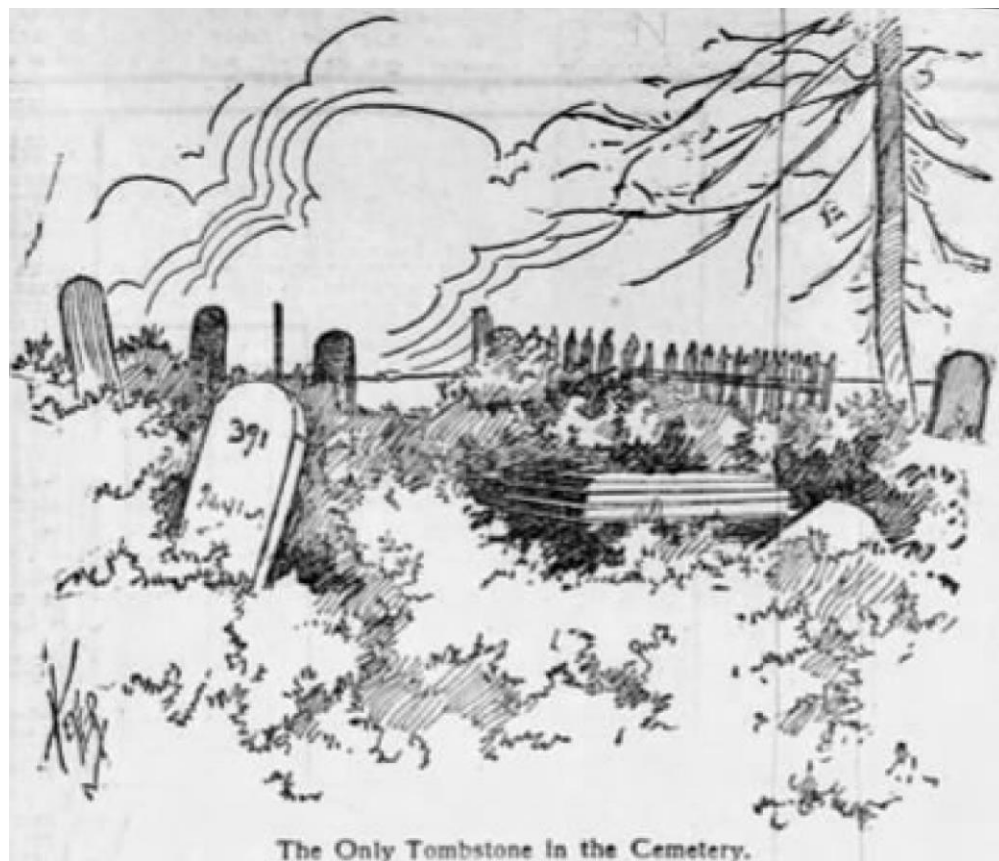


Figure 16: A sketch of the Koch Cemetery in 1894, overgrown with local flora and several toppled headstones. Inscription reads “*The Only Tombstone in the Cemetery*” (At Quarantine 1894).

By 1899, public concern had shifted to fighting TB. The construction of a hospital dedicated to TB treatment was first proposed in St. Louis newspapers in 1899 (Starkloff). Before Koch was officially opened in 1910, the hospital was primarily used to treat smallpox – it was referred to as both Quarantine Hospital and Smallpox Hospital during this intermittent period. In 1908, an article was published titled “City Employee Sleeps Once too Often in Quarantine Hospital Graveyard.” This article refers to the continued burial of individuals in the cemetery, in this case those who died from smallpox (City Employee 1908). This description notes the lack of visitors and “entire absence of obituary poetry engraved on the marble monuments,” accompanied by a cartoon of the hospital worker sleeping against the headstones (**Figure 17**, City Employee 1908).



Figure 17: Cartoon of a hospital employee sleeping on the gravestones at Koch Cemetery. Inscription reads “*In the graveyard sleeping*” (City Employee 1908)

In 1909, the transition of the Quarantine Hospital to Koch Hospital was announced in the papers (Tuberculosis Foes 1909). At this point, sanatoria were described as the “utopian dream” for tubercular patients, modelled after the medical strategies of the ancient Greeks and Romans, who believed that open air and leisure could cure almost any illness (Starkloff). Despite this optimism, Koch Hospital could not live up to the dream. Almost immediately, St. Louis’

newspapers began reporting patient complaints about the hospital's conditions. In 1913, 32 Koch patients spoke to the paper to protest their "malicious" treatment (32 Koch Hospital 1913). Despite these complaints, the façade of utopia was still peddled to the public. One article written by Superintendent Dwyer, the lead administrator for Koch Hospital, included the following description:

"the old quarantine grounds south of the city ... stood on a high elevation back from the river front, but overlooking the river on one side and a vista of woodland on the other three sides. It had a southern exposure, which is an ideal exposure for a tuberculosis hospital" (Dwyer 1921).

Throughout the years, many articles were written about the condition of the Koch land. A 1920 article called the "cemetery on the grounds a bad feature" that could not be removed from the land (Big Improvement 1920). The poorly constructed buildings from the mid-19th century were torn down in the 1920s to be replaced with new ones. The city TB controller at the time, Dr. Bredeck, recommended that the old patient cottages be torn down and that all of the buildings on the property were so dilapidated that remodeling them would be pointless (Dr. Bredeck 1921). By 1923, some of the old buildings had been replaced with permanent structures (**Figure 18**) and in 1926, the hospital received approval for four more buildings (How City's Tubercular 1923, Koch Hospital Capacity 1926). City health officials tried to pass two \$2,000,000 bonds to improve conditions at Koch, once in 1928 and again in 1930, but this legislation failed (\$2,000,000 Bond Issue 1928, More Hospitals Urged 1930).

To meet the demand for beds, the hospital continued to expand. In 1937, new wards were built for patients, and older "cottages" were torn down (Koch Hospital on Guard 1937). Despite expansions, the hospital was still often overcrowded, and the city refused to fund new construction.

As the hospital fell into dilapidation, its fields became overgrown, and it was briefly repurposed as a nursing home and a women's prison before eventually closing (Shirk 1982, Sutin 1983). In 1983, the *St. Louis Post-Dispatch* published an article advertising an auction held at Koch to allow the public to buy the "merchandise" left behind (Grimes 1983). This was the last time the hospital would be open to the public before being abandoned.



Figure 18: Photograph of new buildings at Koch Cemetery, taken in 1923. The old water tower, the first structure built on the land, can be seen in the distance, near the center of the image (How City's Tubercular 1923)

War Against Disease

The terminology used to describe the repeated epidemics that faced St. Louis during the late 19th and early 20th century was based largely in panic. During epidemics of yellow fever and typhoid fever, the Koch Quarantine Station was featured heavily in the St. Louis papers. Yellow fever reports included lists of new cases, the dying, and the dead. One article included a description of a woman "alone in the weeds by the side of the track" from yellow fever so virulent that "doctors ... refused to go near her" (Yellow Fever 1878a). "Panic," "paralyzed," and "dread" were used to

describe the overall feelings of the public (Yellow Fever 1878a, Quarantine 1878). The number of casualties meant that there were not enough church officials to bless the dead or enough caskets for burial, so bodies piled up in the streets or remained in their homes with their family for days after death (Yellow Fever 1878a, Yellow Fever 1878b). These epidemics were labelled “plagues” by the public, and TB was specifically referred to as the “great white plague” (Yellow Fever 1878a, Dr. W.G. Priest is Dead at the Koch Hospital 1911, Medical and Social Science Team Up Against TB at Koch Hospital 1955, Harris 1963, Cunliff 1921). A paper from 1922 classified St. Louis’s struggle against TB as “18-Year Warfare” (Review of St. Louis Fight on Tuberculosis 1922). In this same vein, papers identified “education of general public and preventive measures [as] necessary to fight disease” (How Other Cities Fight Tuberculosis 1915). It seems that St. Louis was unwilling or unable to implement these measures as effectively as other American cities of the same size. Quarantining was a large part of how infectious disease was fought during each of St. Louis’s epidemics. During the yellow fever epidemic, there were complete shutdowns of schools and businesses, and people were arrested if they attempted to leave the Quarantine Station (Quarantine 1878). Widespread fear and panic reigned over the city as disease decimated the population. Only after the panic associated with yellow fever, typhoid fever, and cholera began to subside, did the fear of TB take over like a blanket of slow deaths across the city. **Figure 19** illustrates



Figure 19: Illustration titled “King of the Ghetto” (1910). The drawing shows Death wielding a scythe labeled “The White Plague” reaching into the homes of St. Louis’ most vulnerable populations.

both the fear of this disease, personified as the grim reaper yielding a scythe labelled “The White Plague,” and the concentration of deaths in neighborhoods facing extreme poverty (“King of the Ghetto” 1910).

The Cost of Care

St. Louis’ most vulnerable citizens were left to suffer the consequences of infectious disease without resources from the city. The city’s biggest concern during epidemics was not to prevent further deaths, but to save money. St. Louis’ newspapers frequently refer to Koch and its patients in terms of how much the hospital cost the city. In 1899, the cost of operating the Quarantine Hospital was listed as “more than \$8,000,000 a year,” which translates to more than \$250 million today (Starkloff 1899). This number may be inflated because in 1938, the cost was reported as \$374,614 a year (Plan to Double 1938). Part of this disparity may be explained by the high cost of long-term treatment of tubercular patients and by the relatively low number of patients present in 1938. In 1958, the cost was \$1,600,000 a year (almost \$15,000,000 today) before changing to \$5,100,000 in 1983 (almost \$14,000,000 today) (Officials to Consider 1958, Sutin 1983).

The failure of the hospital to meet medical standards was often attributed to the city’s reluctance to spend money on Koch’s patients. Newspapers blamed the continued spread of epidemics on the “city’s failure to spend municipal funds ... in preventative and remedial work” (How Other Cities 1915). During the first decade of Koch’s operation, patient requests for transfers to other hospitals with better conditions, such as Mount Vernon Hospital, were frequently denied by the city because it was much cheaper to host patients at Koch (State Board Finds 1920, Charities Board Finds 1920). In 1920, the cost of one week’s care for a Mount Vernon patient was \$7.50

while the cost at Koch was only \$2.74 (State Board Finds 1920, New Report Asks 1920). While patients at Mount Vernon received better care and had better health outcomes, the city continued to divert patients to Koch because it was so much cheaper (Big Improvement Program 1920, More Hospitals Urged). Funneling poor citizens through Koch allowed the city to provide care to the indigent while spending as little money as possible to do so.

Patient Numbers, Hospital Employees, and Death Rates

The *St. Louis Post-Dispatch* reported the 1878 death rate from yellow fever at 4,000 (Yellow Fever 1878a). By 1899, TB had taken over the largest threat facing the public, killing 1,359 individuals (Starkloff 1899). In 1904, “St. Louis had the highest death rate from TB of the 10 largest American cities” (Review of St. Louis 1922). The huge number of patients coming into Koch Hospital and low funding created such desperation that the hospital began to borrow both food and nurses from other hospitals nearby (Bill if Signed 1910). For the next two decades, the rate of TB in St. Louis continued to grow. In 1913, 2,000 people died from tTB, and another 15,000 were infected (Review of St. Louis 1922). In 1916, TB was identified as the leading cause of death (City Health Division 1930). In 1917, 205.4 people in 100,000 were infected (More Hospital Urged 1930). In 1920, 12,000 of city’s children died from the disease despite national decreases in mortality (Dwyer 1921). Despite these high rates, Koch was run by 73 employees and had a capacity of 247 patients, allowing them to treat just 1675 cases in 1919 (Food Intolerable 1920, New Report 1920).

By 1921, one in every ten deaths in the city was caused by TB (How Other Cities 1915, Cunliff 1921). The *St. Louis Post-Dispatch* reported that even in cases where victims did not perish from TB, histology of lung tissues revealed the presence of tuberculosis bacilli (Cunliff 1921). A

steep 30% drop in mortality was reported in 1922 with less than 940 deaths, but the number of active cases needing hospitalization remained high at 9500 (Review of St. Louis 1922). In 1926, Koch hospital administration suggested increasing its capacity to 1,000 patients, but this expansion never happened (Koch Hospital Capacity 1926, \$2,000,000 Bond Issue 1928).

In 1927, 84 in 100,000 were infected, but by 1928, the rate had increased to 100 in 100,000 (More Hospitals Urged). This rise saw the 240 beds in Koch stuffed with 420 patients, again signaling a need for expansion (\$2,000,000 Bond Issue 1928). By 1930, the rate of infection slowed and plateaued at 96.8 out of 100,000 people, yielding 4000 active cases with 828 deaths reported in 1929 and 855 reported in 1928 (More Hospitals Urged 1930). Even so, Koch had a “waiting list of about 60” patients and was suffering a shortage of nurses (More Hospitals Urged 1930, City Health Division 1930). By 1933, deaths had decreased by 26% and 46% of patients admitted to hospitals with TB were able to recover and return home (Deaths Decrease at Koch 1933). By 1936, the waiting list had expanded to 165 patients, and the hospital had just over half of the nurses it needed (Tuberculosis Official Urges 1936). In 1937, there were only 3,298 active TB cases in the city (68.8 per 100,000), and the 712 who needed hospitalization were stuffed into the 550 beds at Koch (Koch Hospital on Guard 1937, Plan to Double 1938). By 1940, the infection rate hit 54.9 per 100,000 and the Koch waiting list had increased to 190 names (Record Lows 1940, Empty Beds 1942). These 190 people faced extreme frustration because Koch had 200 unoccupied beds (Empty Beds 1942). Their denial was based on the fact that the hospital only had 8 doctors and very few nurses (Empty Beds 1942). This labor shortage would plague the hospital for years to come (Koch Hospital Bonus 1949, Harris 1963). By 1955, Koch only treated 877 patients in the course of a year, 152 of whom died (Medical and Social 1955).

Conditions of Care

High death rates, lack of funding, and personnel shortages all contributed to the low quality of care experienced by patients at Quarantine Station and Koch Hospital. Beginning in 1854, the constant unloading of dying individuals from the Mississippi and influx of St. Louis citizens to Quarantine Station put a heavy burden on medical personnel. Too few doctors were available or willing to treat highly infectious patients. Many patients' conditions deteriorated quickly and a report from 1878 noted that "only the very poor people will be left [at the Quarantine Station], and many of those will die for want of attention" (Yellow Fever 1878a, Francis 1879). A young woman suffering from typhoid fever in quarantine killed herself to shorten her inevitable suffering and prevent her children from contracting the disease (At Quarantine 1892). When overrun with infectious disease, the hospital did not have the resources to provide quality care to all of its patients. In 1910, the *St. Louis Post-Dispatch* reported that

"patients had been snaring rabbits in the woods near by and cooking them over open fires on the lawn, and that the stronger patients had to wait on the feebler patients because there had not been enough nurses to attend to all in the beginning" (Bill if Signed 1910).

In response to claims that patients were starving and being neglected, newspapers and medical societies paid fake patients to enter Koch and investigate (Anti-Tuberculosis Board 1912, Board to Act 1912). One of these reports found that Koch was "in some respects, the worst institution of its kind in the United States," and another found "mistakes in giving medicine," "neglect and improper food" such as rotten milk, and a breakout of "smallpox among the inmates" (Anti-Tuberculosis 1912, Board to Act 1912). Despite this evidence of poor conditions, the complaints of patients were largely ignored, and hospital staff suggested that the patients were simply delusional from their diseases, making them susceptible to manipulation by investigators (32 Koch

Hospital 1913). Complaints about conditions continued throughout the history of the hospital. In 1920, the *St. Louis Post-Dispatch* found Koch “unfit for the proper care of tubercular persons who might be cured,” with “inadequate” facilities and that the food was “intolerable” (Patients, Transferred 1920, Food Intolerable 1920, Charities Board Finds 1920, Big Improvement Program 1920). The conditions were so poor that patients claimed they would rather forego care than be treated at Koch (State Board Finds 1920). Instead, they stayed at home, exposing their loved ones to infectious disease and perpetuating the spread (Empty Beds 1941). Investigators described the hospital as “ramshackle” with cottages that “leak when it rains” and “miasmatic fogs” rolling in from the river (State Board Finds 1920, Big Improvement Program 1920).

Treatments

The overwhelming nature of infectious disease in the pre-antibiotic world left doctors without many viable options for treatment. During the yellow fever epidemics, diagnoses were made if yellow impressions appeared on the patient after a physician pressed down on their abdomen (Quarantine 1878). Carbolic acid, now referred to as phenol, was used as a disinfectant (Quarantine 1878). Derived from tar, carbolic acid is a poison which can be absorbed through the skin or inhaled; its corrosive nature can cause severe burns and organ damage (National Center for Biotechnology Information 2021). Early treatments for TB were not much better. In 1895, a doctor named Paul Paquin claimed to have discovered the cure for consumption after 8 weeks of research (He Has Discovered 1895). Dr. Paquin would inoculate a horse with TB under the belief that the “equines species [was] ... naturally immune to the disease” (**Figure 20a**), before returning a few days later to draw blood from the horse (**Figure 20b**) (He Has Discovered 1895). He would use

this blood to create “a reddish amber serum” that could be dripped onto the back of patients, conferring the horse’s immunity to the patient (**Figure 21**) (He Has Discovered 1895).

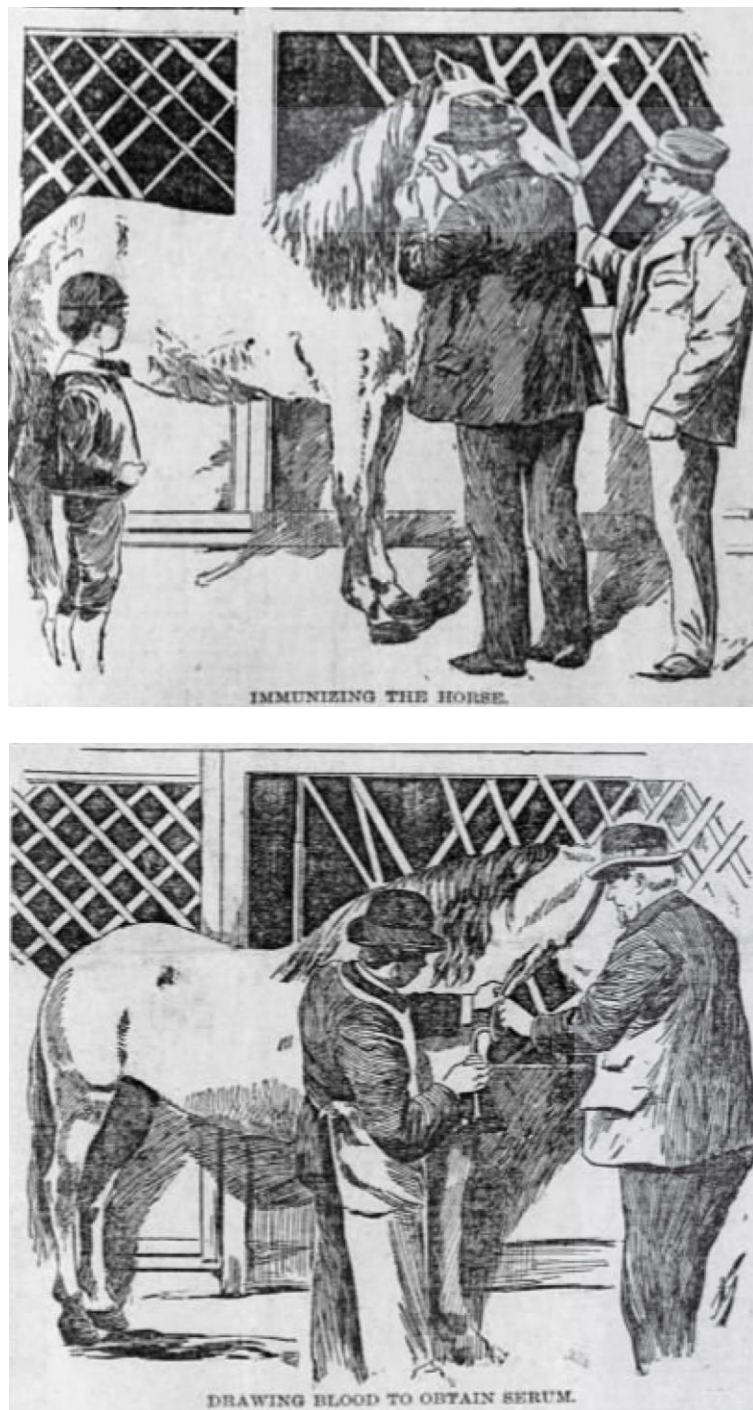


Figure 20: a. top, a sketch of Dr. Paquin injecting a solution containing TB bacilli into a horse while a young boy and another man watch, titled: “*Immunizing the Horse*” b. bottom, a sketch of Dr. Paquin (right) drawing blood from the same horse with the help of an assistant, titled: “*Drawing Blood to Obtain Serum*” (He Has Discovered 1895).



Figure 21: A sketch of Dr. Paquin dripping his horse-blood serum onto the back of a male patient, titled: “*Treating A Patient*” (He Has Discovered 1895).

Unfortunately, this treatment was not particularly effective, leaving tuberculosis patients with one option: moving into a sanatorium with the hope that “fresh air, sunlight, nourishing food, specified hours of rest and regular exercise” would be enough to cure them (Dwyer 1921). That description of Koch’s treatment was rather optimistic, and written by the hospital’s superintendent, Dwyer, around the same time that patients were coming forward with complaints about the facility. The belief in fresh air’s curative potential also saw many of St. Louis’ citizens fleeing to the west coast, where they believed the air was purer (Cunliff 1921). Many tubercular patients also came to their doctors believing that the disease was a hereditary condition (Cunliff 1921). During the first decade of its operation, Koch primarily treated patients with advanced forms of TB who had little chance of surviving, but as the public became more aware of the importance of quarantining, treatment success rates began to increase (Dwyer 1921, City Health Division 1930). Physicians at Koch treated long term patients every few weeks with a pneumothorax refill, during which physicians would puncture the thorax and admit “air into the chest cavity to collapse a lung” (**Figure 22**) (Deaths Decrease 1933, TB – An Ever Present 1945). The staff performed 70 of these

operations a week, including procedures for outpatients (Deaths Decrease 1933). Outpatient services increased to the extent that Koch was treating 496 patients a day during 1933 (Deaths Decrease 1933).



Figure 22: A female patient of Koch Hospital lying in her bed while a doctor and nurse perform a pneumothorax refill, also referred to as an artificial pneumothorax (TB – An Ever 1945)

The average length of stay for Koch patients who survived tuberculosis was two and a half years, with frequent reassessment of their condition using a scale of one to five: one being severe and in need of bedrest, five being almost completely recovered (Weakley 1945, Koch Hospital on Guard 1937). The pneumothorax refill procedure continued and in extreme cases, physicians resorted to thoracoplasty, a resection of the ribs to allow removal of the diseased portions of the lung where abscesses had formed (Weakley 1945). The long-term nature of treatment at Koch prompted the Red Cross to introduce Occupational Therapy (OT) to patients' lives so that upon recovery, they could have some hope of getting a job (Warren 1935, Weakley 1945, TB – An Ever 1945, Medical and Social 1955). The OT program included the creation of a monthly newsletter,

the Koch Messenger, operated by patients, and several courses such as film projector operation (**Figure 23a**), sewing, carpentry (**Figure 23b**), leatherworking, and ceramics (Weakley 1945, Medical and Social 1955). St. Louis' newspapers reported that spiritual (**Figure 24**) and social connections (**Figure 25**) were prioritized by Koch personnel (Medical and Social 1955, TB – An Ever 1945).

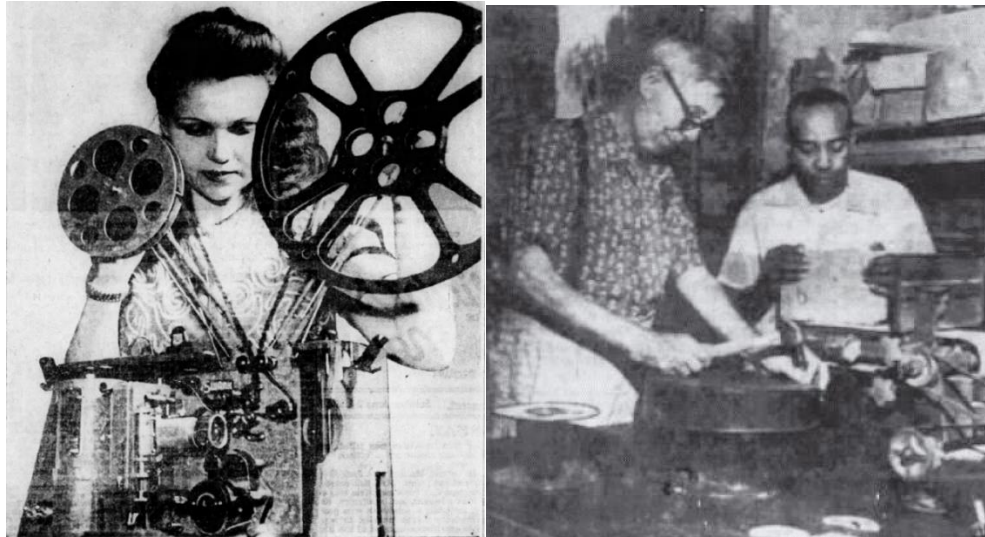


Figure 23: a. A young mother of three who is a patient at Koch Hospital learning how to operate a film projector (Weakley 1945); **b.** Two male patients of Koch Hospital working together in a word-working class (Medical and Social 1955)



Figure 24: A woman who had been a patient at Koch Hospital for one year, praying at the community chapel on the hospital grounds (TB – An Ever 1945)



Figure 25: A series of three photos of Koch patients enjoying each other's company (Medical and Social 1955)

1955 saw the introduction of antibiotics to the treatment regimen at Koch Hospital, which began to decrease the death rate while increasing the number of arrested and discharged cases (Medical and Social 1955). Antibiotics in combination with new surgical procedures resecting tubercular abscesses from patient lungs, decreased the average length of patient stays to under two years (Medical and Social 1955). These successes helped decrease the incidence of tuberculosis throughout St. Louis, but by 1963, patients were already being readmitted with “acquired resistance to the drugs” they had previously been treated with (Harris 1963).

Racial and Socioeconomic Disparities

As noted previously, only the poorest of St. Louis' citizens were sent to Quarantine Station and Koch. They were sent knowing that they were likely to die there (Yellow Fever 1878a). Hospital wings were segregated, and in cases where there was a shortage of beds, white patients were given priority (Quarantine 1878, More Hospitals Urged 1930, Deaths Decrease 1933). In 1945, the *St. Louis Globe-Democrat* published a photo of the black women's ward at Koch, describing it as “sunlit,” which was in reality overcrowded and dim (**Figure 26**) (TB – An Ever 1945). Racialized rhetoric was commonly associated with St. Louis' epidemics. “Russian Jewish

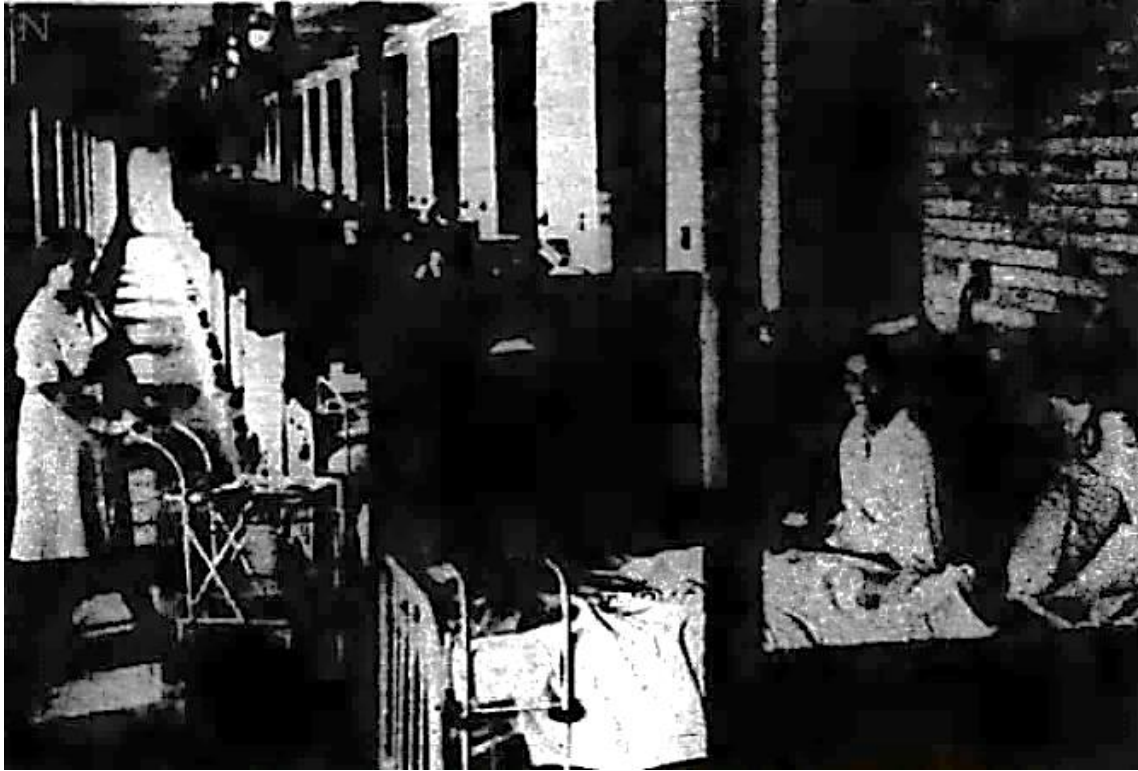


Figure 26: The “sunlit” “colored women’s ward” at Koch Hospital. A nurse is pictured at the foot of one of a long series of tightly packed beds. A patient is visible in the foreground, sitting up in her bed (TB – An Ever 1945)

refugees” were blamed for the introduction of typhoid fever to St. Louis’ population (At Quarantine 1892). Medical authorities identified population growth in the black community as a leading cause of illness in the white community (More Hospitals Urged 1930). In 1921, the death rate of St. Louis’ black population was three times higher than that of the white population, and by 1930, the rate rose to five times higher than that of the white population (Cunliff 1921, More Hospitals Urged 1930, City Health Division 1930). Black children were 17 times more likely to die than white children (Cunliff 1921). The *St. Louis Globe-Democrat* published a map of St. Louis health districts with deaths mapped by household across each region (**Figure 27**) (City Health Division 1930). The neighborhoods primarily occupied by black citizens experienced a significantly higher concentration of deaths under extremely crowded living conditions where people lived in poverty (City Health Division 1930).



Figure 27: A map of St. Louis' health districts with deaths mapped by household. The most concentrated regions are poor neighborhoods with a large black population (City Health Division 1930).

The patients at Quarantine Station and Koch Hospital were continually overlooked by the city officials who were responsible for their care. Requests for more funding, more beds, and more medical personnel were repeatedly denied. The continual use of the Koch site and its cemetery demonstrate the apathy of the city towards both the living and the dead who occupied those grounds. St. Louis, one of the ten largest cities in the United States at the time, was unwilling to provide adequate treatment to its most indigent citizens and failed to apply preventative measures, such as education, against infectious disease. The racialized rhetoric and widespread fear portrayed in St. Louis' newspapers gave city officials someone to blame for their failures: the city's people of color, who were already suffering disproportionately from infectious diseases.

CHAPTER V

DISCUSSION

A Review of Osteological and Archaeological Methods

One goal of this study was to assess the applicability of existing osteological methodology to a highly fragmentary and commingled collection with a low recovery rate. The degree of fragmentation significantly limited osteometric analyses and rendered approximately 12 percent of the fragments unidentifiable. Most of the unidentifiable fragments originated from the diaphyses of long bones. The Koch crania were severely affected by taphonomic deformation and fragmentation, impeding reliable osteometric or morphoscopic cranial estimation of sex (see **Figure 28** as an example).

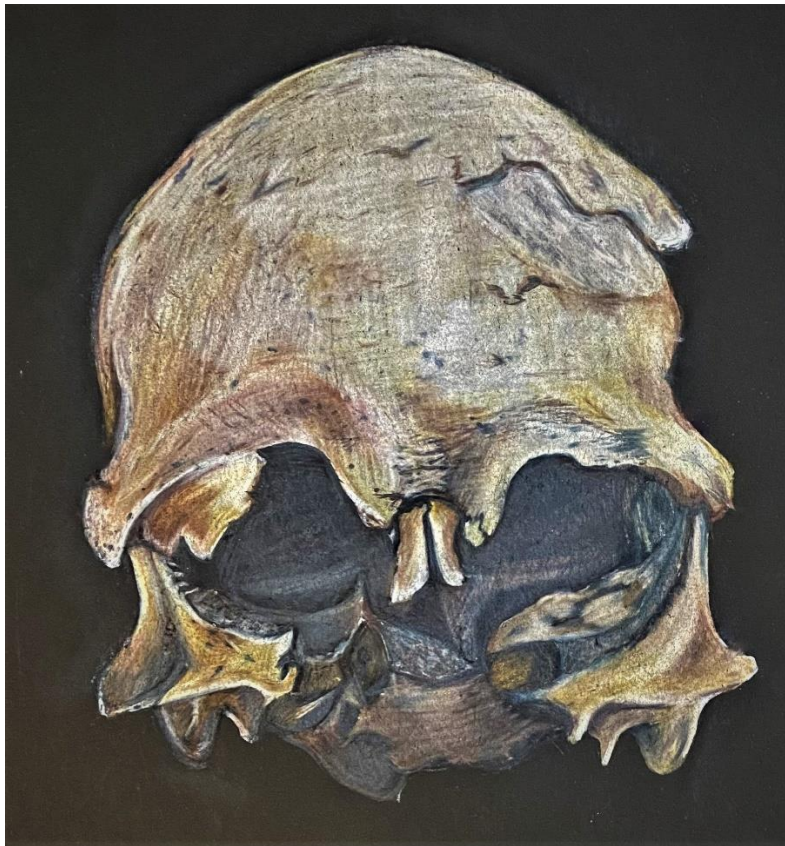


Figure 28: Author illustration of a cranium from Koch Cemetery demonstrating significant fragmentation and deformation.

The landmark method was more effective than the zonation method, and easier to apply to the Koch fragments. The zonation system uses 27 zones to represent the skull, while the landmark system uses 82 landmarks. With a high degree of fragmentation, the landmark system provides higher resolution data, better representing what portions of each bone are present. Each method requires that the observer count a zone or landmark if >50% of it is present. This presence or absence was much easier to determine for individual landmarks than for an entire zone, particularly for elements with complex geometry, such as the os coxa.

Fragmentation obfuscated osteometric results of pair-matching, joint articulation, and element reassociation. The exclusionary power of these tests was limited for this collection, and even in cases where fragmentary test using breadth and width were available, the Koch remains were too damaged for useful exclusions to be made.

As apparent from the results of BRI calculations, the recovery rate for this excavation was very low, with less than half of the skeletal elements from the 40 ± 18 individuals being recovered. The estimated MNI reflects this poor recovery rate, suggesting that only 17 individuals are represented in the sample, which is below the 95% confidence interval for MLNI. At the high end of the MLNI confidence interval, the Koch sample could represent 58 individuals, which would still be very few considering the 18,000 bodies believed to be buried on the land.

The poor archaeological practices used during the excavation of these remains severely hinders investigations into the identities of these 40 ± 18 individuals represented in this sample and prevents any association between these remains and the specific location in which they were buried. It also precludes our ability to complete future excavations of remaining elements belonging to these individuals, and of other individuals buried in the same grave. Without

information on the location of this mass grave, future excavations will require time and resources be dedicated to relocating inhumations.

Treatment of the Dead

Failure to use best practices when exhuming mass graves perpetuates the dehumanization of already marginalized individuals. For the individuals represented in the Koch collection, both their burials and exhumations were dehumanizing and devoid of dignity. As evident from demographic and historical records for the individuals buried at Koch, the cemetery contains many immigrants, people of color, and almost all individuals were of low socioeconomic status. During the late 19th and early 20th centuries, these individuals were forced to live in the ‘ghettos’ of St. Louis, in overcrowded neighborhoods that were a perfect breeding-ground for the infectious diseases that decimated their populations. Upon becoming sick, indigent patients were sent to Quarantine Station and Koch Hospital to die and be buried with no records of their final days. This renders the dead nameless amongst their peers who died under the same circumstances, particularly when they were thrown into ever-expanding sinkholes.

As noted in At Quarantine (1894) and City Employee (1908), the Koch Cemetery was used for continuous burials of the dead for decades. The hospital commissioner specifically referred to burials as bodies being “dumped” into the sinkhole (At Quarantine 1894). Hospital personnel were clearly aware of the condition of the mass graves, but nothing was done to remedy the situation. The treatment of the dead at Koch Cemetery is clearly in violation of cultural and ethical standards for burials. The living have obligations to properly identify the dead, respectfully bury them, and avoid damaging the remains (Moon 2016, Ranta and Takamaa 2007). These obligations were clearly not met for the 18,000 individuals who were buried in Koch Cemetery. On top of being

thrown into mass graves from the surface, the victims at Koch Cemetery were purposefully placed into graves that were actively being destroyed by the shifting earth. No gravestones were placed to mark burials, preventing families from visiting their loved ones. The living are unable to mourn their loved ones when the circumstances of burial do not align with cultural norms, particularly when it is evident that the bodily integrity of the dead has been violated (Kilonzo and Hogan 1999, Eppel 2014, Rosenblatt 2015). St. Louis' war against disease was fought in the city's poorest neighborhoods and many of these marginalized individuals are among the 18,000 nameless dead buried at Koch Cemetery.

As seen in studies of European Black Death cemeteries, cultural responses to high death rates become a new form of burial ritual, reflecting the ability of the living to cope. St. Louis clearly had a very poor response to its epidemics and was unwilling to put in the time and money to see each of its citizens treated and buried in a respectful manner. Koch Cemetery's burial practices were horrendous even when compared to burial trenches in Venice where victims of the plague were thrown in from the surface, becoming tangled in the grave (Tran et al. 2011). At Koch, the time was not even taken to dig a trench – sinkholes took the place of meaningfully prepared graves. This contrasts with the emergency burial practices of Londoners. The York Mint cemeteries used carefully prepared graves with each individual meticulously placed to maintain their dignity. Other than dumping bodies into sinkholes, no effort was expended in the inhumations at Koch.

Just as burial conventions demand that the dead be treated with respect, exhuming mass graves should be driven by a desire to restore the dignity and individuality of the victims that lie within. Careful exhumations are a form of care for the dead (Rosenblatt 2015, Haglund and Sirkin 2002). In this case, the individuals buried at Koch were not buried or exhumed with care, denying

them any sense of individuality, which further marginalizes individuals who were ostracized during life based on racial/ethnic group and socioeconomic status. Just as important as respecting the dead is fulfilling an obligation to tell their story, which can be incredibly powerful when their narrative contributes so strongly to modern societal and political issues (Verdery 1999, Moon 2016). In the case of Koch Cemetery, even though exhumations were not performed according to best practices, the stories of patients and conditions of their remains have highlighted the consequences of unequal access to healthcare. The city of St. Louis' failure to provide proper healthcare and relief for widespread poverty among people of color and citizens with low socioeconomic status led to the systematic destruction of their most disenfranchised populations during epidemics.

Social Disparities in Healthcare and Health Outcomes

Who is Worth Caring For?

Until the 1930s when epidemic rates began to decline, St. Louis' poor were sent to Quarantine Station and Koch Hospital knowing they were going to die. For some individuals, this meant dying in the streets while doctors walked past them (Yellow Fever 1878a, Francis 1879), and for others, it meant dying in overcrowded wards (see **Figure 26**, TB – An Ever 1945). The city of St. Louis repeatedly denied requests for funding from Koch Hospital, including money to pay employees, feed patients, and improve hospital infrastructure. Patients were given rotten food, exposed to other infectious diseases, and neglected by medical staff who did not have the time or resources to care for them. When patients desperately requested transfer to other hospitals that cost the city more money per patient, they were denied. Complaints from patients were quickly downplayed in the newspapers by public health officials who claimed they were delusional

because of their disease. If the hospital ran out of beds, patients stayed in their homes, exposing their loved ones to disease. Calls for the city to fund public education about infectious disease and preventative measures went unanswered. The city of St. Louis was unwilling to spend money on its poorest citizens, who were deemed unworthy of quality healthcare.

Sex-Based Disparities

Female patients at Quarantine Station and Koch Hospital died 7.42 years younger than male patients, reflecting a clear difference in treatment favoring men over women. Historically, women's illnesses have not been taken as seriously as men's, often being disregarded as simple women's reproductive health issues or cases of hysteria, the catch-all term for negative consequences of a woman's moral failings (Kent et al. 2012). Even in modern medicine, physicians consistently fail to properly diagnose and treat chronic and infectious conditions in women (Manuel 2018, Kent et al. 2012). Despite improvements in women's health outcomes and overall social status, women are more likely to die from a disease than men presenting with the exact same symptoms (Kent et al. 2012). Clearly in the case of Koch Cemetery, women were not afforded the same resources or care as men, creating the 7.42 year gap in age at death. While this significant gap in life expectancy no longer exists, the systemic biases in favor of males still exist and have very real consequences on the lives of women within the American healthcare system.

Healthcare Disparities Based on Ethnic/Racial Group

In the American healthcare system, people of color are deemed less important and less worthy of quality care. At Koch Hospital, medical resources were purposefully allocated to white patients before black patients and today, although most physicians do not consciously make this

choice, the same is true. The disparity in resources available to black individuals versus white individuals at Koch led to the 10.88-year difference in age at death between these two groups. Black individuals were more likely to die at all ages than white ones. The high burden of infectious disease in minority populations led to negative health outcomes and high death rates. Immigrants had a higher age at death than non-immigrants. The cause of this phenomenon is unclear, but it may be due to better access to healthcare in their home countries or strong community ties once they arrived in the United States.

The widespread poverty and poor living conditions in black and immigrant neighborhoods exposed them to higher rates of transmission, morbidity, and mortality. Rather than acknowledging the preexisting social structures of discrimination and marginalization as causes of disparate death rates, the city of St. Louis blamed infectious disease on perceived behavioral and moral failings within populations of immigrants and people of color (At Quarantine 1892, Institute of Medicine 2002a). This blame was extended onto the African American community during the 20th century as TB swept through the nation, and again during the 1980s with the HIV/AIDs epidemic. Throughout the COVID-19 pandemic, we have seen the same blame being placed onto minority populations, particularly Asian and African Americans. The racialized rhetoric presented in media during the St. Louis epidemics reflected the social perception of the city's racial/ethnic groups and the unfortunate biological realities imposed upon these groups. The American healthcare system is built upon discrimination and a racialized distribution of resources, as reflected in the history of Koch Cemetery. Unequal access to care based on socially constructed barriers has created significant health consequences for minority and low socioeconomic status populations.

CHAPTER VI

CONCLUSIONS

Koch Cemetery is the resting place for over 18,000 victims of infectious disease from the most indigent neighborhoods of St. Louis, Missouri. Between 1865 and 1910, the cemetery served patients of the Quarantine Station, a makeshift hospital for the treatment of the repeated epidemics of yellow fever, typhoid fever, cholera, etc. that swept through the city. After 1910, Koch Hospital was built to treat tuberculosis, and its patients were buried at the cemetery. The 50-acre plot of land along the Mississippi River on which the cemetery, Quarantine Station, and Koch Hospital are all located is prone to sinkholes, which gave hospital personnel the opportunity to simply dispose of bodies without having to dig graves. The sinkholes were continuously used throughout the 19th and early 20th centuries, with the movement of the earth significantly commingling and fragmenting remains. When remains were exposed due to the sinkhole shifting in the 1960s, faculty from the University of Tennessee, Knoxville excavated 832 fragments of human remains which were placed into storage until January of 2019.

Due to a lack of archaeological notes and historical records for Koch Cemetery, the goals of this study were to decommingle and estimate the number of individuals present in the collection, and to use archival records to reconstruct the site history, including patient demographics, treatments, conditions at the hospital, and cultural perceptions of infectious disease. Osteological analyses were conducted using the zonation and landmark inventory methods, MNI and MLNI estimations, and visual pair-matching. Osteometric pair-matching, joint reassociation, and element reassociation were attempted, but were largely unsuccessful due to the degree of fragmentation. Archival records revealed 550 death records for individuals buried at Koch Cemetery and searches of the three largest St. Louis newspapers (*The St. Louis Post-Dispatch*, *St. Louis Globe-Democrat*,

and *St. Louis Star and Times*) revealed that the conditions at the hospital were miserable and inadequate for proper care.

MNI calculations yielded 17 individuals, while MLNI calculations estimated 40 individuals, with a 95% confidence interval between 22 and 58 individuals. Of the 550 individuals discovered in archival records, most were male (71.5%), and most were white (59%), and approximately 45% were immigrants. When age at death averages were compared by sex and racial/ethnic group, I found that women died 7.42 years younger than males, and black individuals died 10.88 years younger than whites. Interestingly, immigrants died 8.43 years older than non-immigrants, which may be due to better healthcare in their home countries or the strengths of their communities once they were in the US.

Historical research revealed that Quarantine Station and Koch Hospital served St. Louis' poorest populations, but the city was unwilling to properly fund their care. Repeated requests from patients, investigative health boards, and journalists for improvements at Koch went unanswered. There was a persistent shortage of beds and medical personnel. When patients were fed, they were often given rotten food. Experimental treatments which risked the health of patients were used until the 1950s when antibiotics were introduced. Hospital personnel continued to bury patients in the sinkholes on the land and were often sent down into the mass graves to cover up remains exposed by the shifting earth.

Newspapers reported disparities in death rates based on race and socioeconomic status, noting that black individuals of all ages were more likely to die from infectious disease than white individuals. The epidemics that swept through St. Louis were most devastating in neighborhoods with high poverty rates and population densities. Newspapers and the general public blamed minorities for epidemics, believing that behavioral and moral failings based on racial stereotypes

were the reason for the disease. In reality, systematic failures of the city of St. Louis to provide equal access to healthcare to all of its citizens is the root cause of the disparate health outcomes for its poorest, blackest neighborhoods. The allocation of resources to white males before all others forms the basis of the American healthcare system. The consequences of unequal access to healthcare are still clear in the modern COVID-19 epidemic. The most marginalized people in our society are those who are most likely to suffer from both chronic and infectious disease.

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APPENDIX

Zonation and Landmark Systems Guide

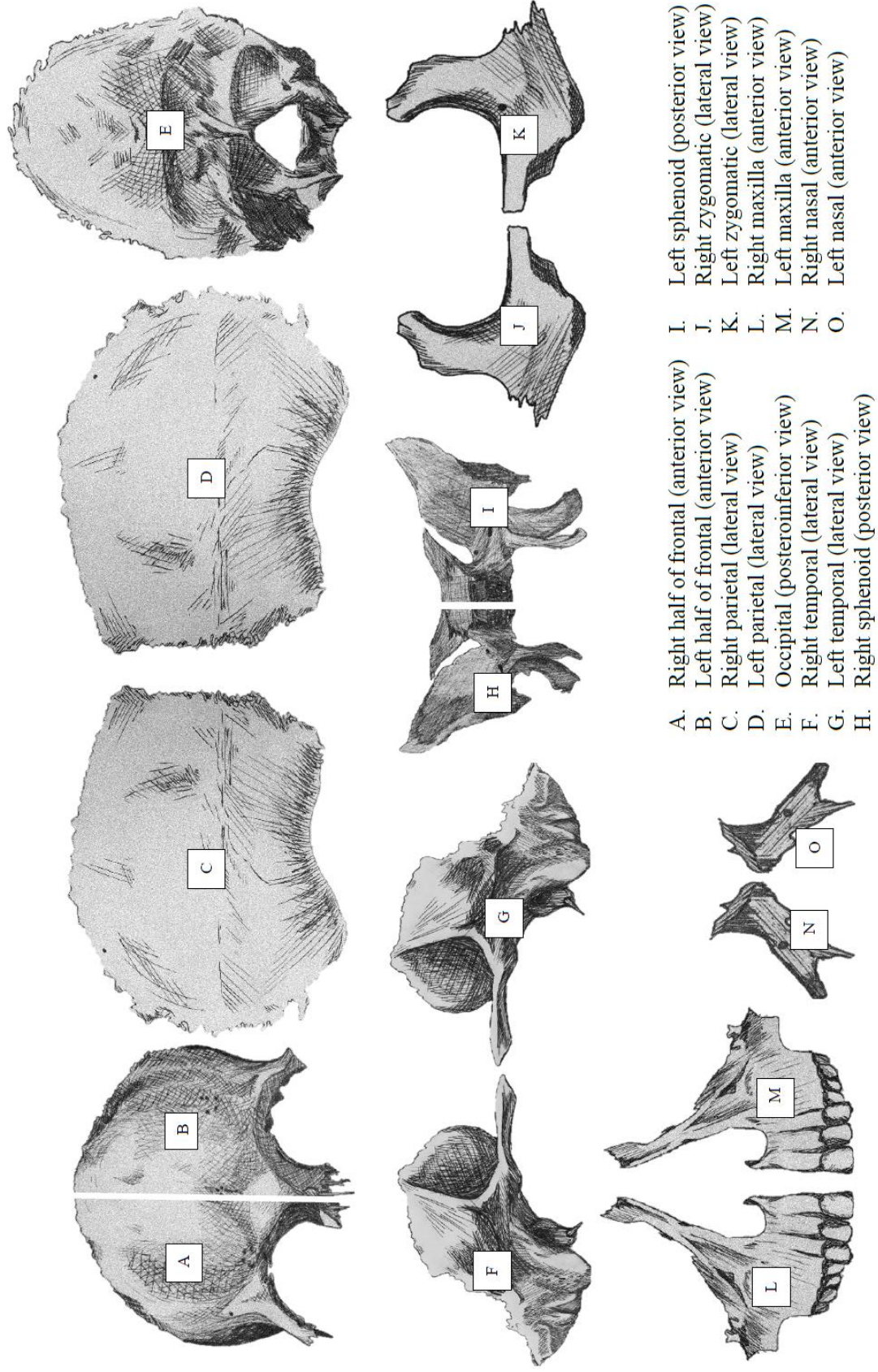
All illustrations are by author. Zonation system guide is modified from Knusel and Outram (2004), and landmark system is modified from Mack et al. (2016).

Zonation System Guide

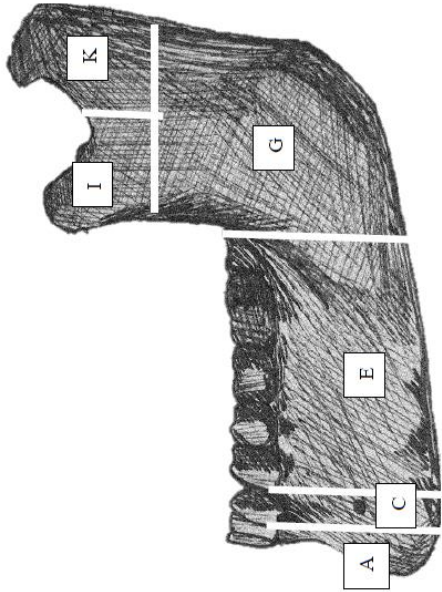
Table 7: Zonation System Appendix Guide

Guide	Section	Page
Cranium	Z.I	b
Mandible	Z.II	c
Os Coxae	Z.III	c
Sacrum	Z.IV	d
Humerus	Z.V	d
Radius	Z.VI	e
Ulna	Z.VII	e
Femur	Z.VIII	f
Tibia	Z.IX	f
Fibula	Z.X	g
Talus and Calcaneus	Z.XI	g

Z.I. Cranium



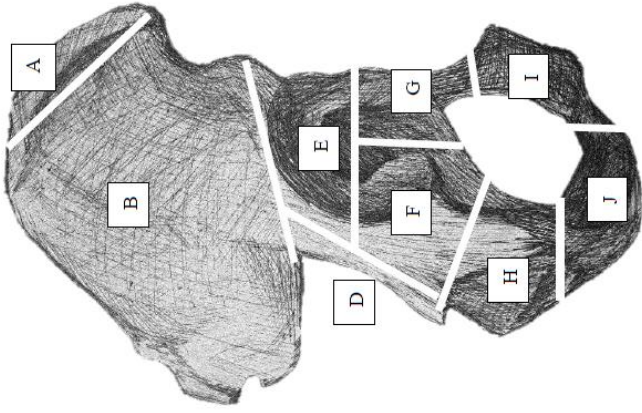
Z.II Mandible



Lateral view of Mandible

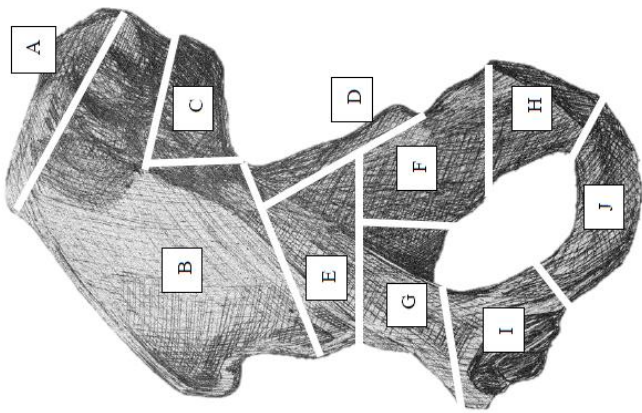
- A-B. Right and Left: mental eminence, alveoli of incisors, incisors
- C-D. Right and Left: canine alveolus, canine, and portion of horizontal corpus
- E-F. Right and Left: majority of corpus, alveoli for premolar and molars, premolars and molars
- G-H. Right and Left: gonial angle and inferior portion of vertical ramus
- I-J. Right and Left: coronoid process
- K-L. Right and Left: mandibular condyle

Z.III Os Coxae



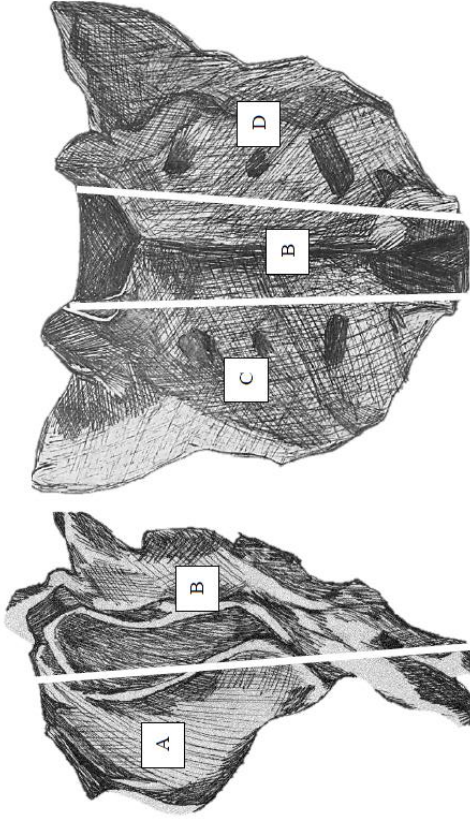
Lateral and Medial View of Right Os Coxae

- A. Iliac crest
- B. Body of ilium
- C. Auricular surface of ilium
- D. Ischial spine
- E. Iliac portion of acetabulum
- F. Ischial portion of acetabulum
- G. Pubic portion of the acetabulum and iliopubic ramus
- H. Ischial tuberosity
- I. Pubis
- J. Ischiopubic ramus



Z.IV

Sacrum

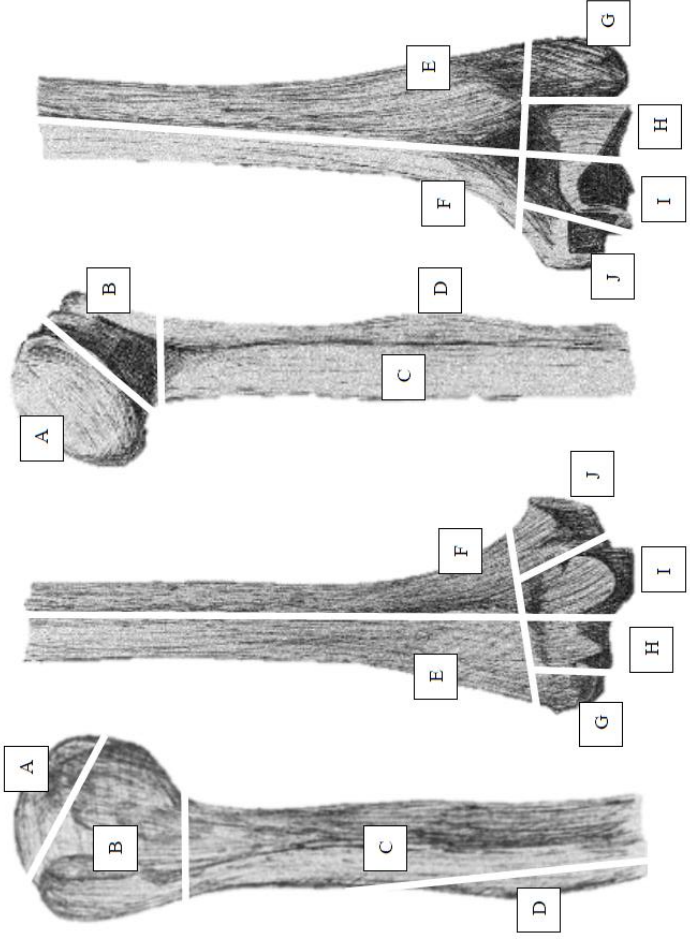


Lateral and Posterior View of Sacrum

- A. Ventral Sacrum
- B. Dorsal Sacrum
- C. Left Alae
- D. Right Alae

Z.V

Humerus

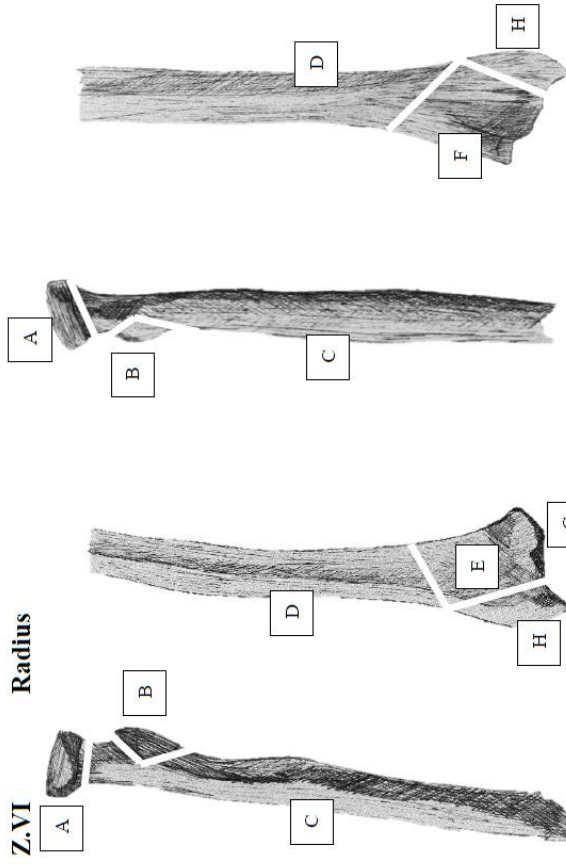


Anterior (left) and Posterior (right)

- A. Head
- B. Tubercles and Neck
- C. Proximal Shaft
- D. Deltoid Tuberosity
- E. Left Distal Diaphysis
- F. Right Distal Diaphysis
- G. Lateral Epicondyle
- H. Medial Epicondyle
- I. Capitulum
- J. Trochlea

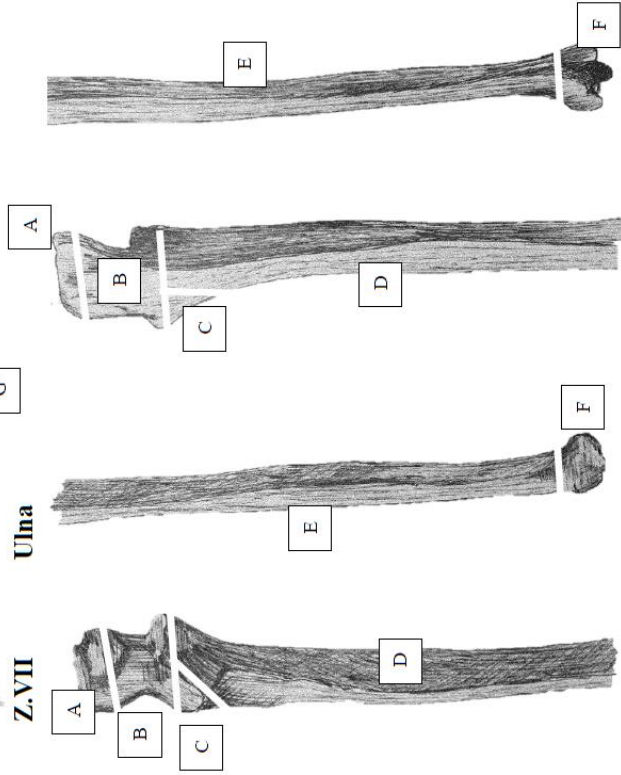
Z.VI

Radius



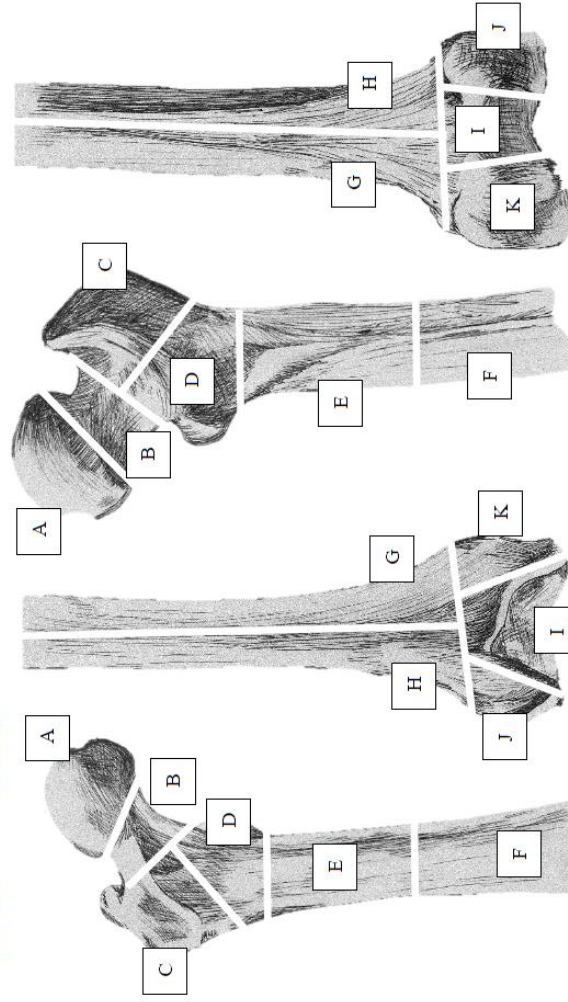
Z.VII

Ulna



Z.VIII

Femur



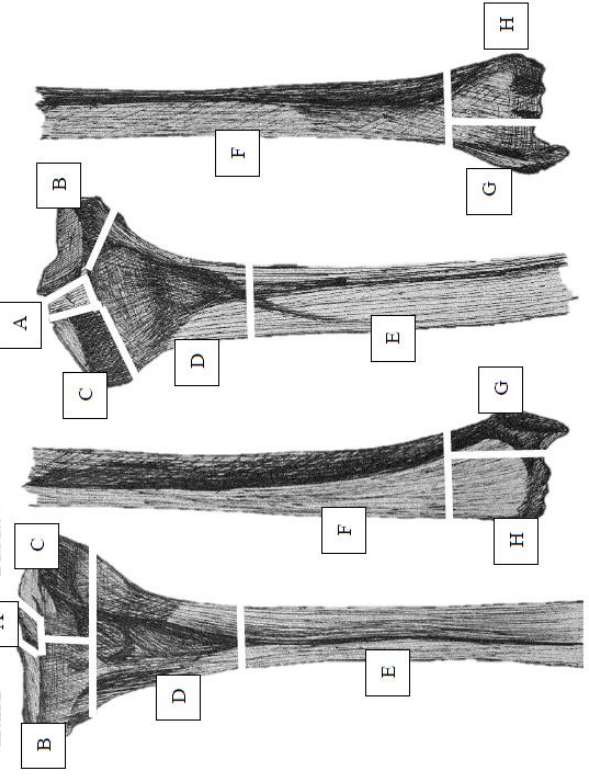
Anterior (left) and Posterior (right)

- A. Head
- B. Neck
- C. Greater Tubercle
- D. Lesser Tubercle
- E. Proximal Diaphysis Portion with Gluteal Line
- F. Proximal Diaphysis Beneath Gluteal Line Fusion with Linea Aspera
- G. Lateral Distal Diaphysis
- H. Medial Distal Diaphysis
- I. Patella Surface and Intercondylar Fossa
- J. Medial Condyle and Epicondyle
- K. Lateral Condyle and Epicondyle

f

Z.IX

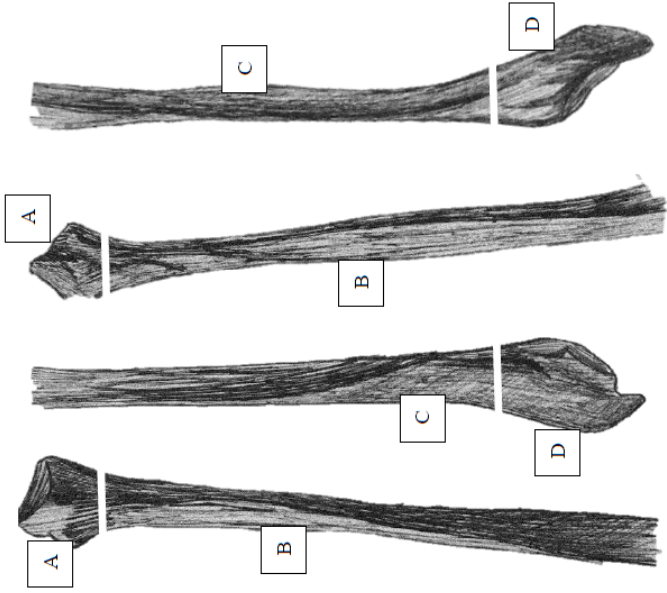
Tibia



Anterior (left) and Posterior (right)

- A. Intercondylar fossa
- B. Medial Proximal Condyle
- C. Lateral Proximal Condyle
- D. Portion of Diaphysis with Tibial Tuberosity
- E. Proximal Diaphysis Beneath Tibial Tuberosity
- F. Distal Diaphysis
- G. Medial Malleolus
- H. Area of Fibular Notch

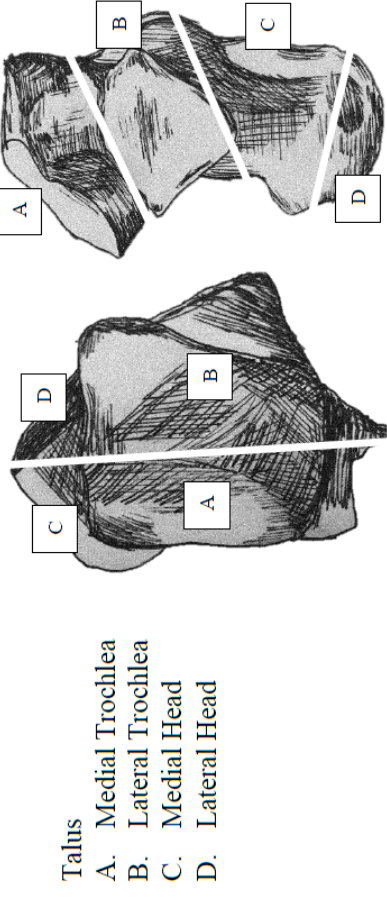
Z.X Fibula



Anterior (left) and Posterior (right)

- A. Head
- B. Proximal Diaphysis
- C. Distal Diaphysis
- D. Lateral Malleolus

Z.XI Talus and Calcaneus



Talus

- A. Medial Trochlea
- B. Lateral Trochlea
- C. Medial Head
- D. Lateral Head

Calcaneus

- A. Anterior Talar Articular Surface and Sustentaculum Tali
- B. Posterior Talar Articular Surface
- C. Body of Calcaneus
- D. Calcaneal Tuberosity

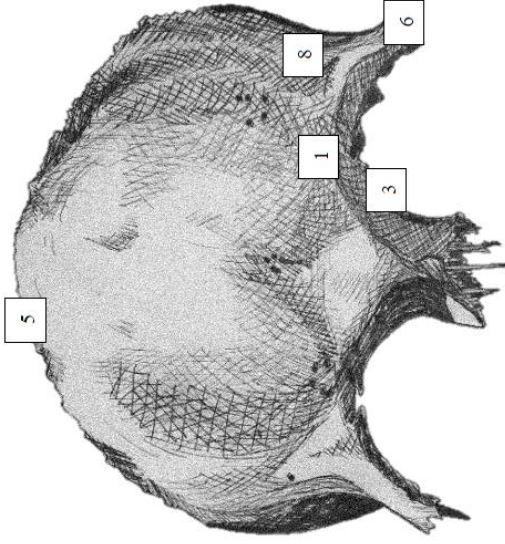
Landmark System Guide

Table 8: Landmark System Appendix Guide

Guide	Section	Page
Cranium	L.I	i-k
Frontal	L.I.1	i
Temporal	L.I.2	i
Parietal	L.I.3	j
Occipital	L.I.4	j
Maxillofacial Bones	L.1.5	k
Mandible	L.II	k
Os Coxae	L.III	l
Sacrum	L.IV	m
Humerus	L.V	m
Radius	L.VI	n
Ulna	L.VII	n
Femur	L.VIII	o
Tibia	L.IX	o
Fibula	L.X	p
Talus and Calcaneus	L.XI	p

L.I.1

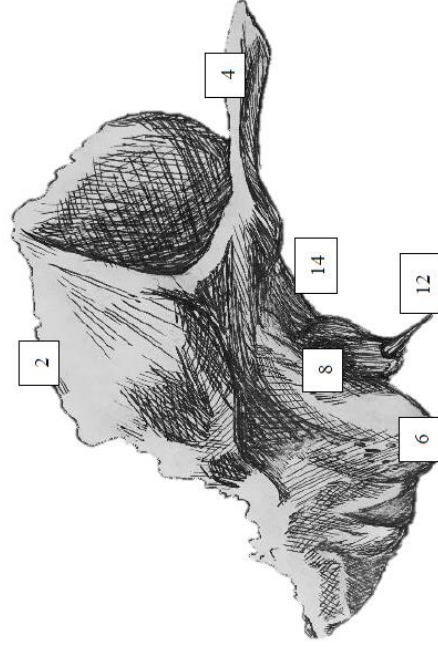
Frontal



1. Left Superciliary Arch
2. Right Superciliary Arch
3. Left Supraorbital Margin
4. Right Supraorbital Margin
5. Frontal Coronal Suture
6. Left Frontal Zygomatic Process
7. Right Frontal Zygomatic Process
8. Right Frontal Temporal Line
9. Left Frontal Temporal Line

L.I.2

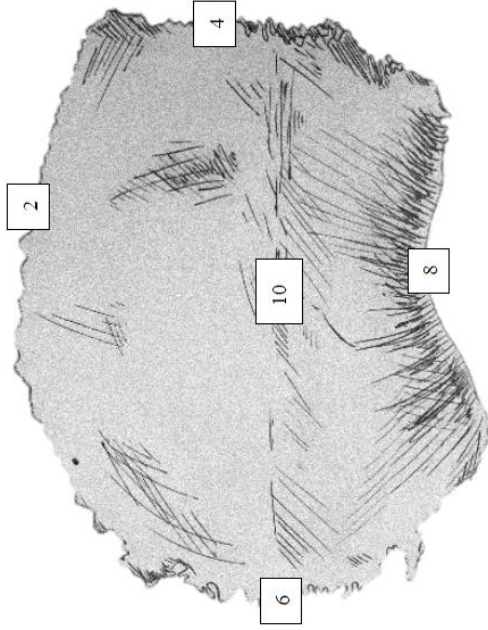
Temporal



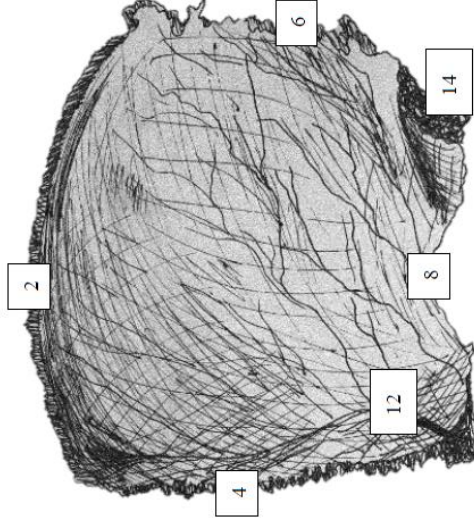
1. Left Temporal Squamous Portion
2. Right Temporal Squamous Portion
3. Left Temporal Zygomatic Process
4. Right Temporal Zygomatic Process
5. Left Mastoid Process
6. Right Mastoid Process
7. Left External Auditory Meatus
8. Right External Auditory Meatus
9. Left Internal Auditory Meatus
10. Right Internal Auditory Meatus
11. Left Temporal Styloid Process
12. Right Temporal Styloid Process
13. Left Mandibular Fossa
14. Right Mandibular Fossa

L.L.3

Parietal

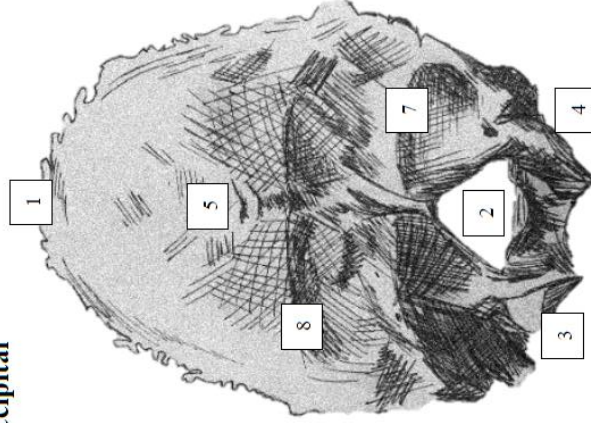


1. Left Sagittal Suture
2. Right Sagittal Suture
3. Left Parietal Coronal Suture
4. Right Parietal Coronal Suture
5. Left Parietal Lambdoid Suture
6. Right Parietal Lambdoid Suture
7. Left Parietal Squamous Portion
8. Right Parietal Squamous Portion
9. Left Parietal Temporal Line
10. Right Parietal Temporal Line
11. Left Meningeal Grooves
12. Right Meningeal Grooves
13. Left Sagittal Sulcus
14. Right Sagittal Sulcus

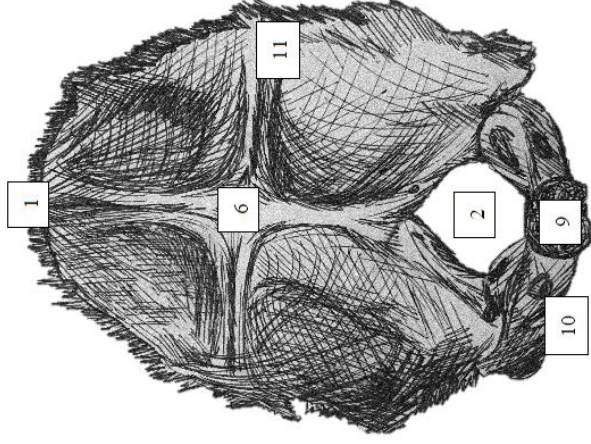


L.L.4

Occipital

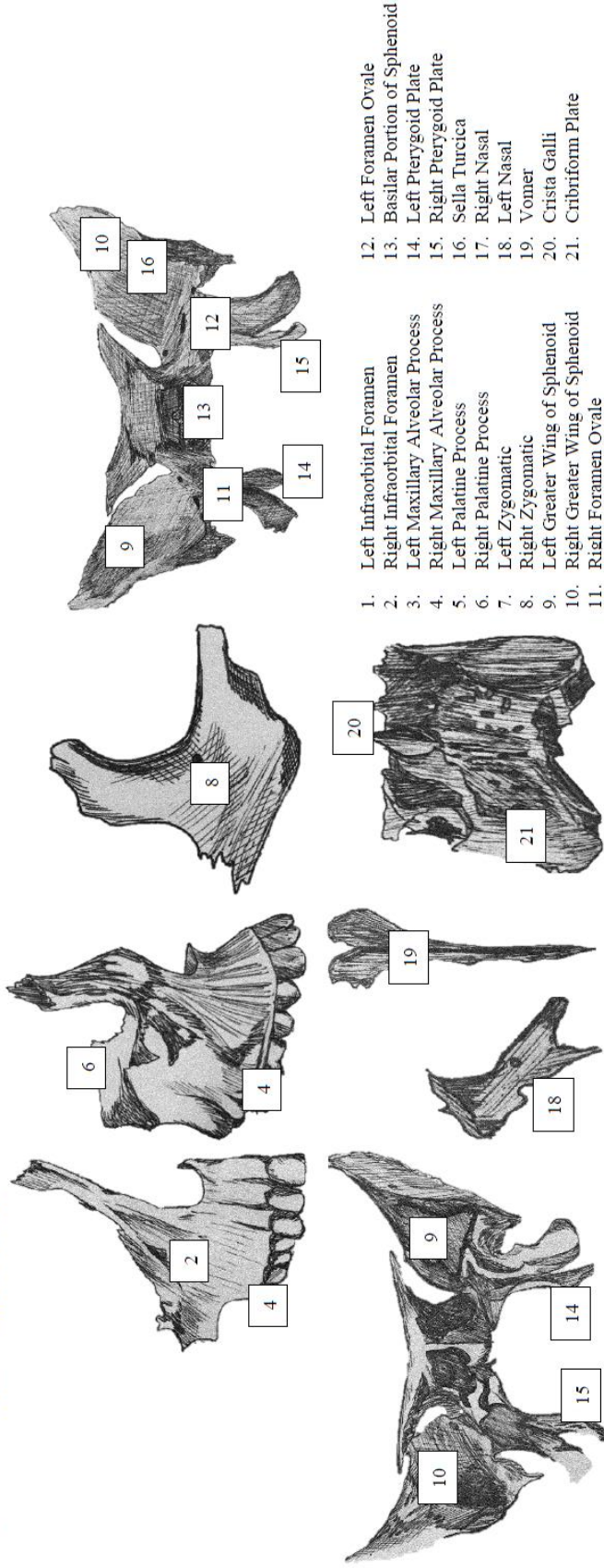


1. Lambdoid Suture
2. Foramen Magnum
3. Left Occipital Condyle
4. Right Occipital Condyle
5. External Occipital Eminence
6. Cruciform Eminence
7. Inferior Nuchal Line
8. Superior Nuchal Line
9. Basilar Portion
10. Hypoglossal Canal
11. Transverse Sulcus

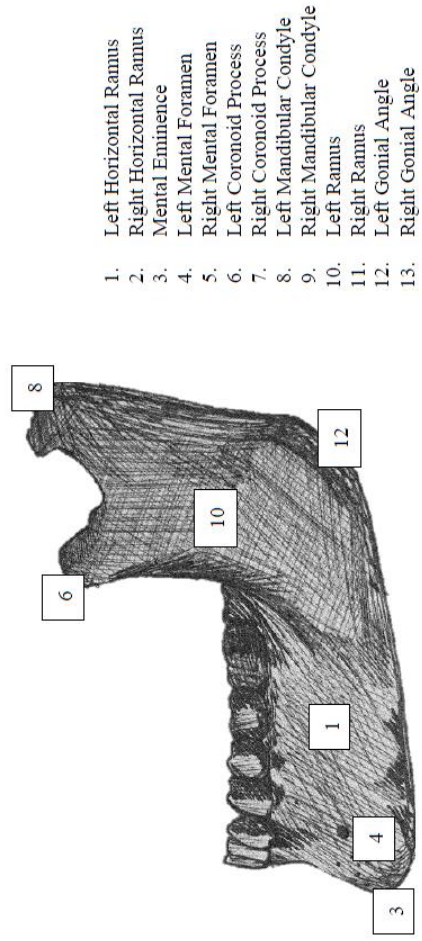


L.I.5

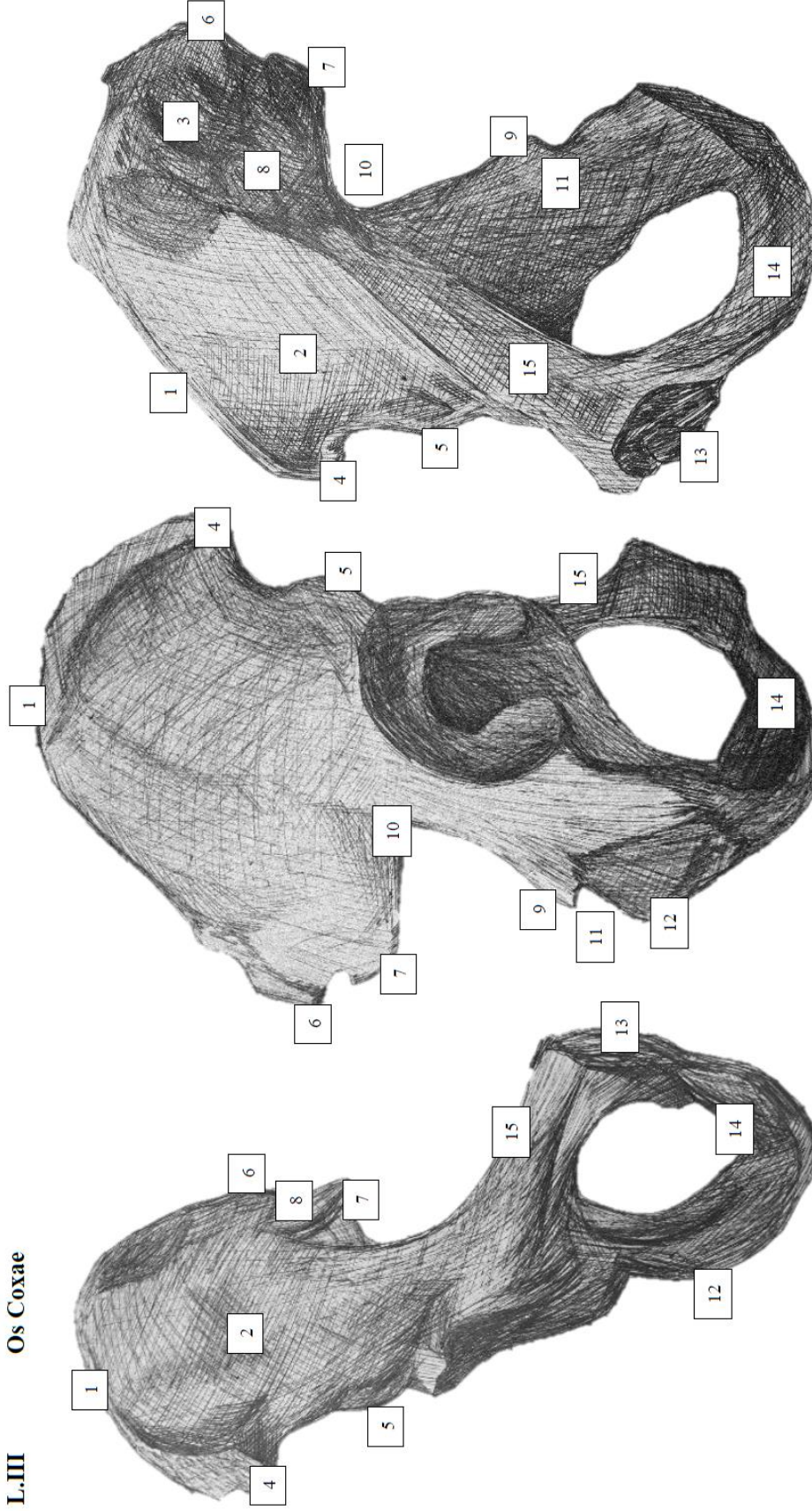
Maxillofacial Bones



L.II Mandible



L.III Os Coxae



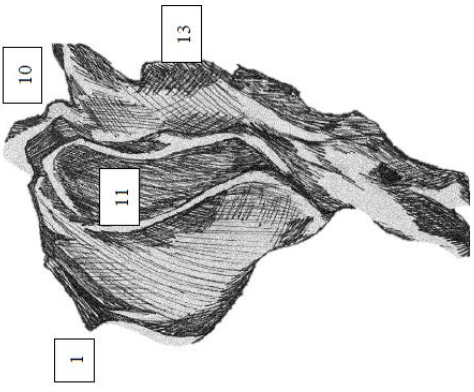
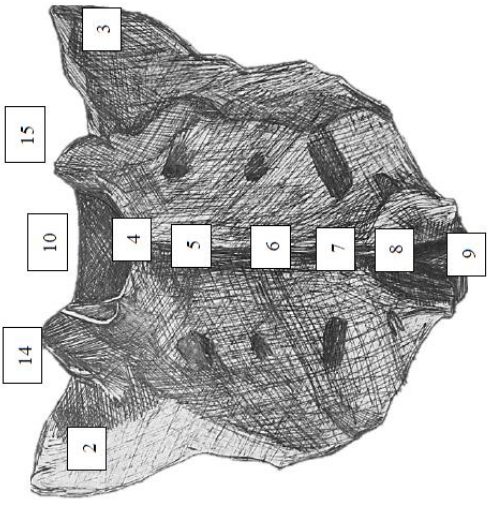
1. Iliac Crest
2. Iliac Fossa
3. Iliac Tuberosity
4. Anterior Superior Iliac Spine
5. Anterior Inferior Iliac Spine

6. Posterior Superior Iliac Spine
7. Lunate Surface
8. Auricular Surface of the Ilium
9. Ischial Spine
10. Greater Sciatic Notch

11. Lesser Sciatic Notch
12. Ischial Tuberosity
13. Symphyseal Face of the Pubis
14. Ischiopubic Ramus
15. Iliopubic Ramus

L.IV

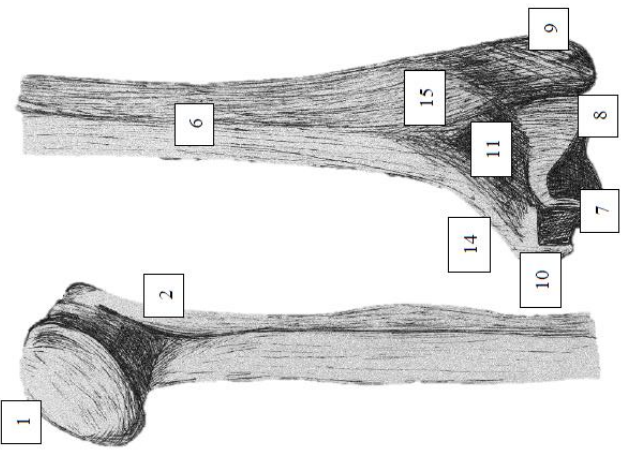
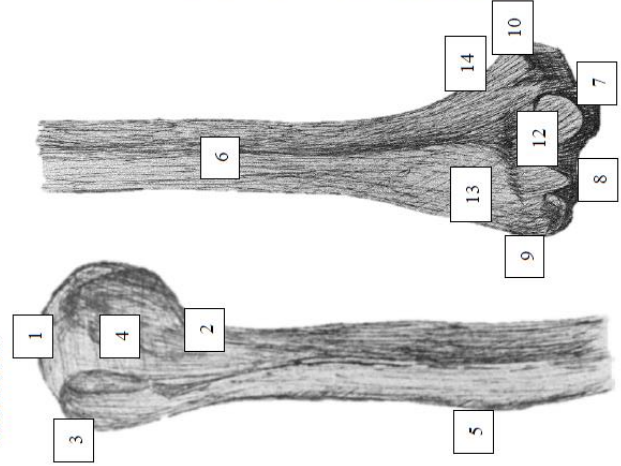
Sacrum



1. Sacral Promontory
2. Left Alae
3. Right Alae
4. 1st Sacral Body
5. 2nd Sacral Body
6. 3rd Sacral Body
7. 4th Sacral Body
8. 5th Sacral Body
9. Sacral Hiatus
10. Sacral Canal Entrance
11. Left Sacral Auricular Surface
12. Right Sacral Auricular Surface
13. Median Crest
14. Left Superior Articular Process
15. Right Superior Articular Process
16. Coccyx (not pictured)

L.V

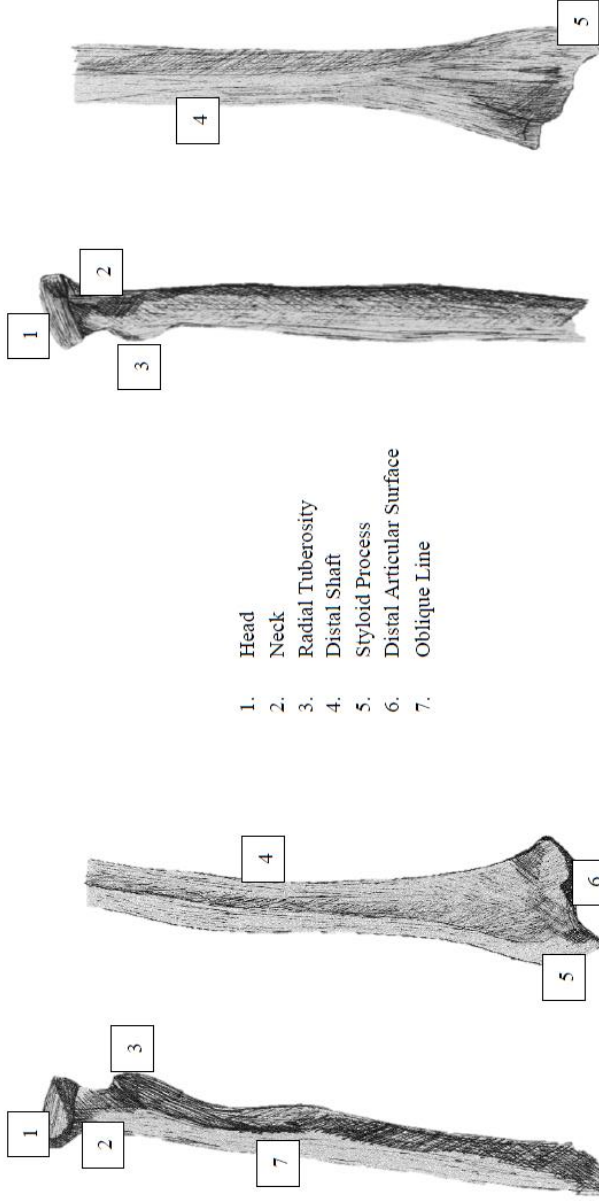
Humerus



1. Head
2. Surgical Neck
3. Greater Tubercle
4. Lesser Tubercle
5. Deltoid Tuberosity
6. Distal Shaft
7. Capitulum
8. Trochlea
9. Lateral Epicondyle
10. Medial Epicondyle
11. Olecranon Fossa
12. Coronoid Fossa
13. Lateral Supracondylar Ridge
14. Medial Supracondylar Ridge
15. Flattened Posterior Surface of Distal Humerus

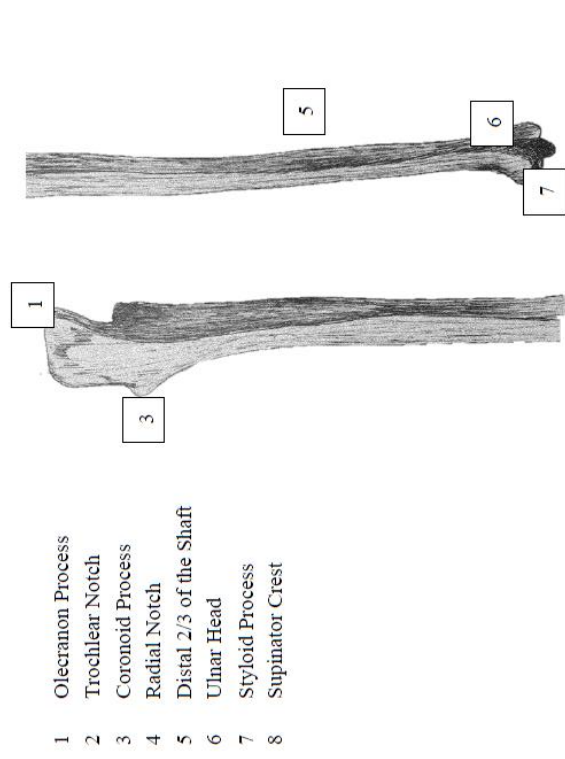
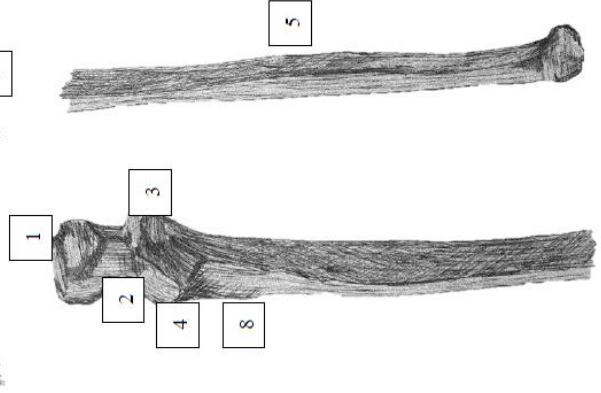
L.VI

Radius



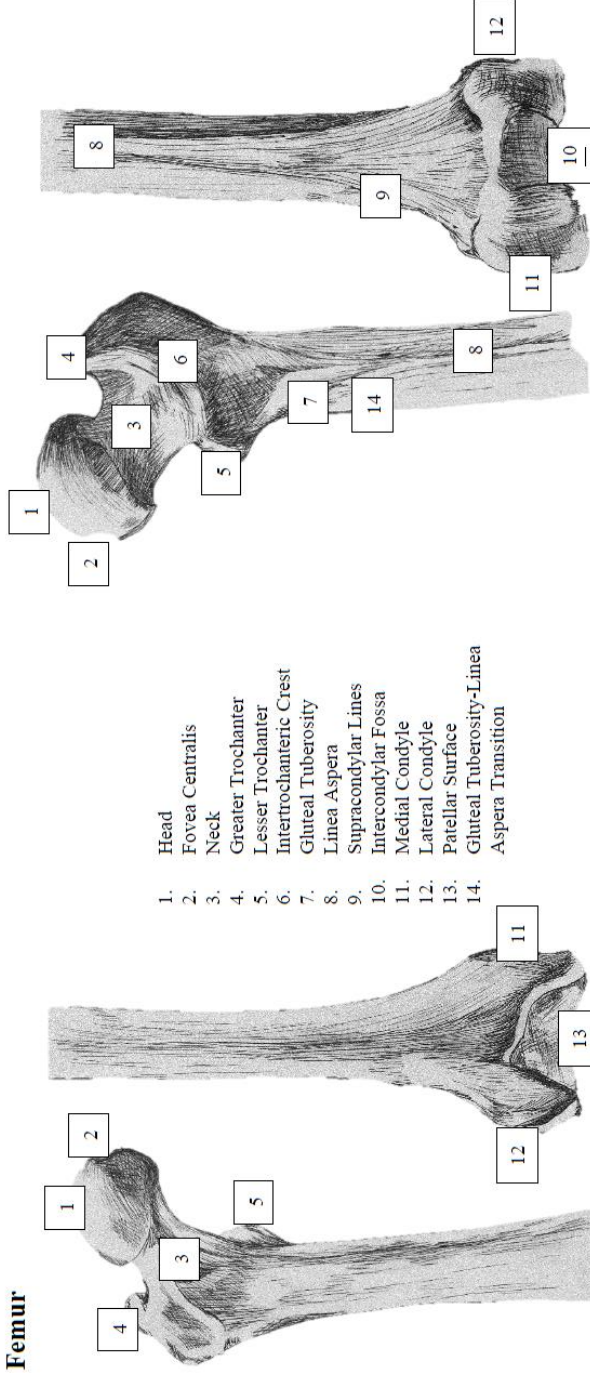
L.VII

Ulna



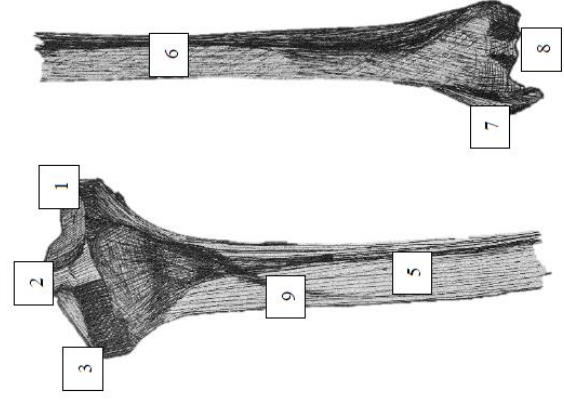
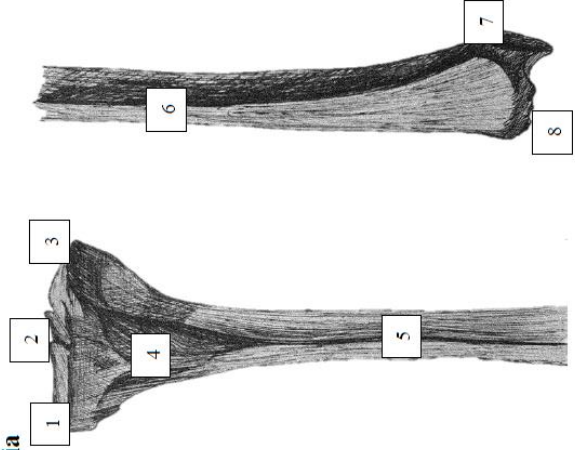
L.VIII

Femur



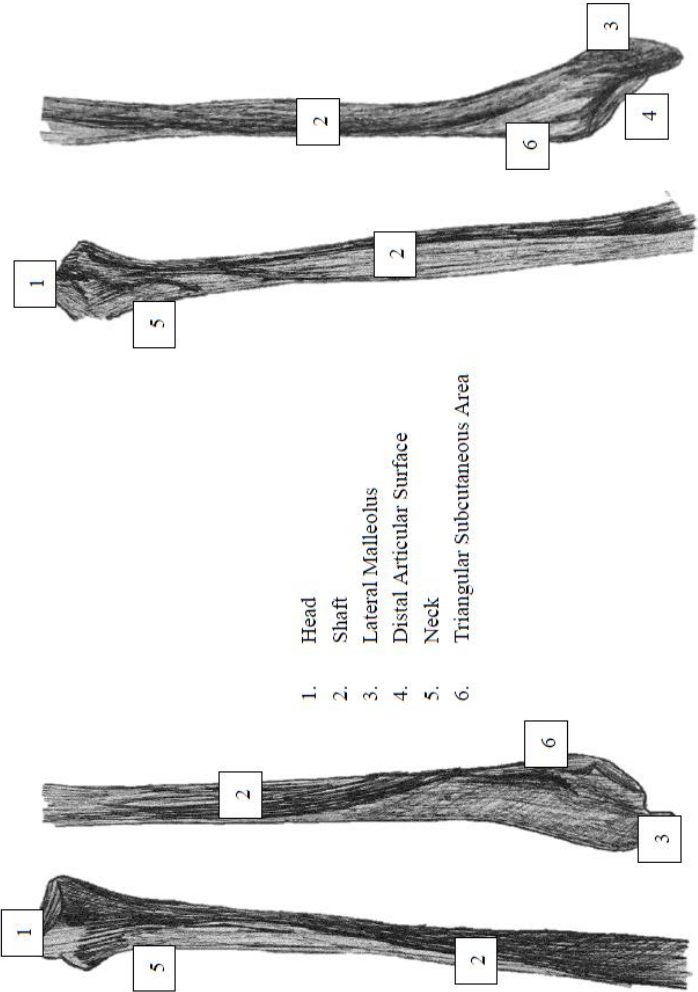
L.IX

Tibia



L.X

Fibula



L.XI

Talus and Calcaneus

