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That Other Form of Madness: A Multidisciplinary Study of Infectious Disease Within the Milwaukee County Poor Farm Cemetery

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THAT OTHER FORM OF MADNESS: A MULTIDISCIPLINARY STUDY OF INFECTIOUS DISEASE WITHIN THE MILWAUKEE COUNTY POOR FARM CEMETERY

by

Helen M. Werner

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ABSTRACT

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Helen M. Werner
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Between the years of 1882 and 1925, the Milwaukee County Poor Farm buried several thousand members of Milwaukee's indigent population in what would later be designated Cemetery II. In 1991 and early 1992, after discovery of the cemetery during construction of parts of the Milwaukee Regional Medical Center, 1,649 burials were excavated. The graves had long been abandoned and the headstones bulldozed, leaving a register of burials without any obvious way of associating each individual with their identity. A copy of the register is curated at the University of Wisconsin-Milwaukee Archaeological Research Laboratory. The Milwaukee County Poor Farm was a vast complex of buildings that included a county hospital, a tuberculosis sanitarium, an orphanage, and housing for the poor. The graves typify those of pauper burials, containing few grave goods and therefore few ways in which to reassociate the individuals with their names.

My dissertation is one of many collaborative projects that focus on the Milwaukee County Poor Farm Cemetery and aims to restore as much identity and humanity as is possible to these long forgotten, disenfranchised citizens of Milwaukee County. My contribution to this project is to use traditional bioarchaeological methods, combined with molecular biology, and incorporate material culture analysis and historical research to provide a comprehensive look at what it was like to live in the early 20th century in Milwaukee County as a pauper with an

infectious disease. This dissertation also presents molecular biological data from dental calculus rather than bone tissue as a way of moving away from destructive analysis for DNA work in bioarchaeology. In order to apply molecular biological techniques to archaeological material, it is typical to rely on extracting DNA from bone tissue, since other material may not be available. Regardless of how much bone is needed, and for ancient DNA in particular this can be up to a gram, this is a destructive technique that is being applied to an individual's remains in most instances without their consent. Dental calculus, calcified dental plaque, is now being explored as a way of obtaining DNA from a deceased individual that would not destroy any of that person's biological material. However, with the ability to analyze the DNA from a deceased person can come the assumption that we have all of the information that we need about them and their cause of death. This dissertation takes a holistic approach to bioarchaeology and combines the discussion of post-mortem agency and theories of suffering to advocate for a new paradigm for bioarchaeological work.

In order to meet the aforementioned goals, I developed a multi-scalar research protocol. First, I analyzed the individuals from the MCPFC who had vertebrae present to look for signs of tuberculosis. I then extracted bone and dental calculus from their remains and extracted DNA from both sources. I used Polymerase Chain Reaction to examine the extracted DNA for evidence of *Mycobacterium tuberculosis*, *Brucella* species, and *Streptococcus pneumoniae*. The results from this DNA analysis were analyzed using Fisher's Exact Tests and were combined with the material culture data from the 1991/1992 excavations. Finally, in order to support the goals of this dissertation and of the larger MCPFC project, I used the data at hand to reconstruct the lives of the poor who suffered and died from infectious diseases in a time before effective treatment was available.

For

Theodore

and

Holden

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Chapter 1

Disease, Death, and Burial in the Milwaukee County Poor Farm Cemetery

"They say you die twice. One time when you stop breathing and a second time, a bit later on, when somebody says your name for the last time." – Banksy

For years, the people interred in the Milwaukee County Poor Farm Cemetery lay forgotten. The grave markers had long since been razed when in 1991, while building an ambulatory care center on the property of the new hospital that stood on the grounds, the builders unearthed burials and Milwaukee County was forced to reckon with what had been ignored for almost sixty years. The subsequent 1991/1992 excavations disinterred 1,649 individuals. The Register of Burials from the cemetery list 7,226 people who were buried there between the years 1882 and 1925. The Milwaukee County Poor Farm Cemetery is comprised of four individual cemeteries. Just seven miles west of the City of Milwaukee in Wauwatosa, WI, the cemeteries are part of the larger Milwaukee County Poor Farm complex. Cemeteries I, III, and IV, remain largely undisturbed. Cemetery II was the cemetery that was excavated in the 1991/1992 excavations, and is the focus of this dissertation. Figure 1.1 shows the map and the time during which the cemeteries were in use.

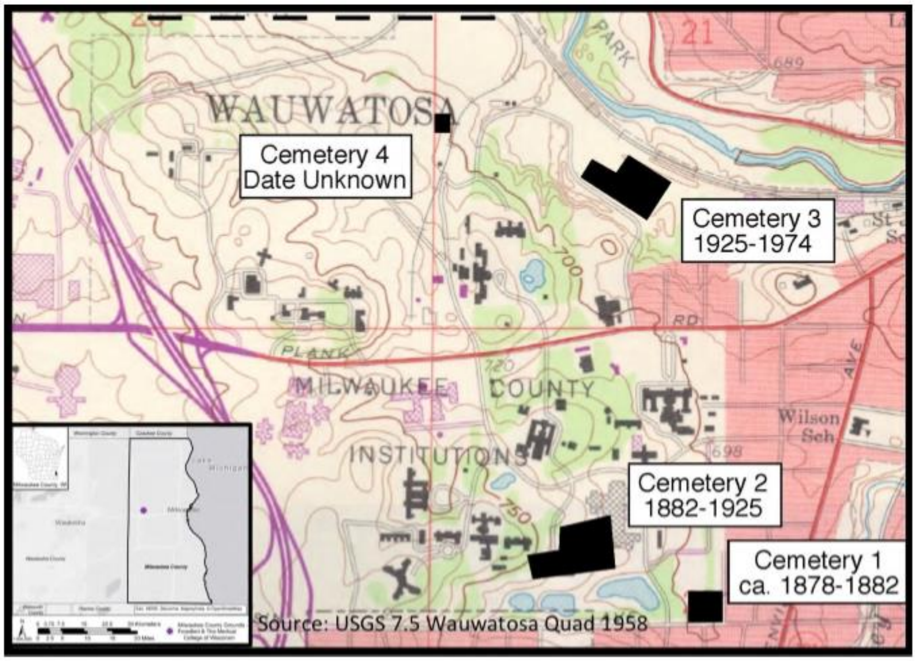


Figure 1.1. A map of the Milwaukee Poor Farm Cemeteries and their use dates (Richards et al. 2016:17)

These cemeteries contained the graves of Milwaukee's poor who could not afford a burial, those who lived at the Milwaukee County Poor Farm complex, and those from the coroner's office whose bodies were left unclaimed. Most of the burials lack grave goods or any material culture. By far the most common items are safety pins from simple shrouds (Richards 1997: 212). The remains of the people themselves tell tales of hard labor, infectious and nutritional diseases, and in a number of cases, of having been utilized by early 20th century medical students being trained to study anatomy (Richards et al. 2016: 33, Drew 2018: 37).

This dissertation examines the relationship between molecular and anatomical signs of tuberculosis in 89 of the individuals from the MCPFC. The DNA from two other respiratory diseases, brucellosis and pneumonia, are also examined in the skeletal remains via Polymerase Chain Reaction using material from both the vertebrae and the dental calculus. I hypothesized there is a correlation between the DNA in the dental calculus and the DNA from the vertebral bone. I have already shown in Werner (2015) that there was no significant predictive link between osteological lesions and tuberculosis DNA. In this dissertation I hypothesize that a more significant predictive value will be represented by the osteological lesions compared to the DNA derived from dental calculus collected from individuals interred in the Milwaukee County Poor Farm Cemetery. One goal of the thesis was to demonstrate the use of dental calculus in bioarcheology as a replacement for destructive techniques.

In addition to tuberculosis, two other agents of respiratory disease were analyzed in this dissertation, *Brucella* species and *Streptococcus pneumoniae.* There is evidence that both of these respiratory pathogens can cause infections which spread to the vertebral column, similar to tuberculosis (Jeong et al. 2014: 22, D'Anastasio et al. 2011: 150). Previous studies, including my 2015 thesis, have questioned the predictive value of assuming prior tuberculosis infection of an individual based upon gross anatomical changes observed in the skeletal vertebral column (Müller et al. 2015). One of the possible reasons for the lack of a correlation between lesions and disease DNA is that the lesions themselves were caused by a pathogen other than tuberculosis. In this dissertation, Brucellosis and a common bacterial cause of pneumonia were chosen due to the known presence of these two diseases in the area at the time as well as the similarity of their symptoms with those of tuberculosis.

This research project is part of the broader Milwaukee County Poor Farm Cemetery project currently underway at the University of Wisconsin-Milwaukee. The MCPFC project is charged with identification of as many of the skeletons under its care as possible, using accurate and ethical science. The project aims to bring the stories of these people's lives to light and return as much dignity as possible to a group of people who were robbed of dignity in life and in burial. My contribution fits within this framework by applying a multidisciplinary research track and an agency-based theoretical approach to examine the action of how tuberculosis and other respiratory diseases are expressed within the MCPFC population. My goals for this dissertation were threefold: first, to apply and compare a non-destructive method of DNA analysis to the results of more traditional methods; second, to use historical research and statistical analysis to enhance the bioarchaeological data and DNA results in order to restore personhood to the people whose bones are discussed here; and finally, to examine the relationship between disease and the type of burial that a person was given in terms of the grave goods that were present and the care that was put into the burial.

The remains of 89 individuals from the 1991/1992 excavations of the Milwaukee County Poor Farm Cemetery were analyzed in 2014 in the course of my master's thesis research (Werner 2015). The presence or absence of osteological lesions consistent with tuberculosis infection were recorded in 89 individuals, 85 of which had DNA extracted from their vertebral bone. The other four individuals did not have enough DNA present from the extraction for a successful PCR run. For the PhD thesis DNA was extracted from the dental calculus for 47 of the 85 individuals. Thirty-eight of the original 85 individuals sampled did not have dental calculus collected due to the absence of teeth or due to the absence of calculus on their teeth.

Bioarchaeology is the study of human remains from archaeological sources. A central theme in bioarchaeology is the idea that the bones left behind are able to tell us something about the individual to whom they belonged (Larsen 2018: 866). Bones, according to Sofaer (2006) can be treated in some ways like another grave good to which an object biography approach can be applied. Chapter 2 of this dissertation discusses the idea that a person's skeletal remains are not necessarily the most informative source of data regarding their lives, but are just one part of an individual history. Additionally, in Chapter 2 I discuss the ways in which the diseased are treated and the ways in which they are buried. The microcosm of life at a tuberculosis sanitarium allowed for both an increased and a decreased practice of individual agency (Schug 2016: 6). The lives that the people included in this dissertation were living were unique in part due to their diseased status, but I argue in Chapter 2 that their identities should not be reduced to their diagnosis and burial.

Chapter 3 of this dissertation provides a look at what life was like in Milwaukee County while the cemetery of the Milwaukee County Poor Farm was in operation. This historical background contextualizes the data presented and gives the reader a look at the particular challenges of people living with infectious diseases at this time. Milwaukee County was unique compared to other large, rapidly expanding, industrial cities at the time, in that it was one of the first cities to appoint a specialized public health officer. This proved beneficial in 1918 during the Great Influenza when Milwaukee fared better than most other urban areas due to good practices and advanced preparation (Bootsma and Ferguson 2007: 7588).

Using the seminal works of Buikstra and Cook (1980), Van Embden et al. (1993), and Kaestle and Horsburgh (2002), in Chapter 4 I outline the history of the study of the bioarchaeology of tuberculosis and how DNA analysis has been used in the last twenty years to augment this area of study. Infectious spinal diseases, including tuberculosis and the two other pathogens that I include in my analysis, can present themselves in subtle ways that make identification difficult. I discuss how diseases move from the respiratory system into the spine, and how this process can present similarly to other diseases. I also present the results of a Bayesian meta-analysis that proposes a more accurate proportion of osteological lesions characteristic of tuberculosis that are positive for IS6110, a DNA marker in the *Mycobacterium* *tuberculosis* genome. This chapter also provides a detailed look at how my bioarchaeological data were collected.

Chapters 5 and 6, the Methods and Results chapters of this dissertation, detail the ways that the bioarchaeological, DNA, and material analyses data were collected and analyzed. The bioarchaeological, DNA extraction, and Polymerase Chain Reaction (PCR) data were all gathered by me during the process of research for this dissertation. The material culture analysis was performed by Richards (1997) and is detailed there. This dissertation takes the material culture information that was gathered by Richards (1997) and provides a statistical analysis of the relationships between the results of Richards and my bioarchaeological and DNA analysis to determine whether there were any links between certain material markers and the diseases identified in this analysis.

The final chapter of this dissertation begins with stories of real people that were either patients in the Milwaukee County Hospital or were buried in the Milwaukee County Poor Farm Cemetery. These stories are critical to understanding what it was like to live with and die of a bacterial infectious disease before the advent of antibiotics. In order to properly do justice to both the goals of the Milwaukee County Poor Farm Cemetery Project and the work carried out by bioarchaeologists concerned with post-mortem agency, the discussion chapter of this dissertation synthesizes the biological data, the material culture analyses, and the real lived experiences of Milwaukee citizens to complete the aforementioned goals of this work.

Chapter 2

Through the Mouths Left Behind: An Archaeological Approach to Suffering

"The dead could only speak through the mouths of those left behind, and through the signs they left scattered behind them."
— Robert Galbraith

The stories of the dead are told through the mouths of the living and as bioarchaeologists, we are one of the means by which their stories are heard (Arnold 2014: 524). The dead do not bury themselves, and the objects that are placed with them in their graves as well as the grave markers and their physical remains were all influenced by the people who buried them. Human burials represent some of the most information-rich archaeological finds, due to the thought and care that went into them, as well as the individuals themselves and any accompanying grave goods. Bioarchaeologists, by focusing on the physical remains of the buried person, often seek to remove the influences of the living who buried the dead in order to get to the heart of the deceased's life and death. Removing the influences of the living, however, is nearly impossible, as even if the deceased had clear wishes for the disposal of their physical remains, those wishes are not always carried out by the ones who bury them (Schug 2016: 3) What we see when we excavate a burial may or may not be an accurate view of the person or even a representative version of the burial ritual (Arnold and Jeske 2014: 326).

The potential is present for bioarchaeologists to reveal the pain and trauma of a person's existence, but this potential is not always lived up to, and is instead often hidden behind scientific rigor (Pollock 2016: 727). The body is seen as another manifestation of a person's life, one to which they had intimate access and the ability to alter. One of the few aspects of the burial which the living play relatively little part in altering is the physical skeleton. Physical alterations to the body after death are, of course, common, but most of these affect the soft tissue of a person's body, leaving the skeleton relatively intact.

This way of thinking about our bodies, as the ultimate record of our existence, is both useful for the science of bioarchaeology and a potential detriment to the understanding of people. The toll that our lives have left on our skeletal remains can be uncommonly useful for interpreting a person's standing at the time of their life and death in the form of age, sex, disease, and physical stature as well as a host of other characteristics. All of these traits influence what a person's life would have been like. However, it is reductionist to end the discussion with a list of such physical characteristics. By assuming that the information that we gain from the age and sex of a person mainly tells us something about their lives, we are ignoring cultural factors both at the time they lived, and how we currently are interpreting this information and applying it according to our own ideas of the past. While the idea of applying current ethnologies and ethnographies to past burial practices can be tempting, we have to resist that in light of the knowledge that people and cultures change rapidly overtime (Arnold and Jeske 2014: 327). The Christian burial that we know of today is potentially vastly different from the one practiced in turn of the century Milwaukee. This is not only because practices change with time, but because the meaning and importance of these practices has changed over time as well. There is evidence that this was not the burial that people at the time wanted, and that should be given greater weight than our own interpretations of past rituals.

Mortuary behavior during the time when Cemetery II was in use, from 1882 – 1925, was significantly different than today. This time period is rooted firmly in a trend referred to as the Beautification of Death (Bell 1990: 54). This was "characterized by ritualized behavior and material objects that idealized death and heaven and prolonged the mourning and memorialization of the dead" (Bell 1990: 54). This often meant an elaborate and prolonged mourning period in which the body was embalmed and laid to rest for a period of time in the family's home (Bell 1990: 57). The body would have been displayed in an ornate coffin or other burial container with intricate clothing and elaborate and beautiful motifs on both the coffin and the headstone (Bell 1990: 57). Death of a family member was kept close to the home. These elaborate and beautiful rituals for the dead were occurring during a time of social stress and provided the living with a sense of safety for their deceased loved ones. "The nineteenth century brought dramatic change and extreme social stress. Struggling to live in an uncertain world, Americans retreated. They idealized and sanctified the home, the family, and the women who formed them" (Pike and Armstrong 1980: 76). Seeing the burials of the MCPFC in the context of the ideal burial trend at the time further emphasizes the distance between this ideal and the type of burial they actually received.

The study of mortuary behavior during the late 19th century and the beginning of the 20th century was rooted in interest in the afterlife and the relationship between burial practices and mourning rituals (Bell 1990: 54). Bell (1990: 54) defines the study of deathways as a separate subset of mortuary theory. Deathways encompasses "the whole cultural system of mortuary behavior, involving emotion, ideology, symbolism, technology, and economy" (Bell 1990: 54). Bell (1990) invokes the theory of deathways in his study of coffin hardware from an Uxbridge, Massachusetts cemetery that was contemporary with MCPFC Cemetery II. His study of the deathways of the Uxbridge Almshouse Burial Ground incorporates the ideas of the people performing the burials, the Beautification of Death, with the studies of normative mortuary behavior during that time period.

The information available to us about mortuary behavior during this time period is prolific. Rooted in an interest and the study of religion, a renewed emphasis was placed on what previous generations had done when burying and mourning their dead. A. L. Kroeber in 1927 wrote that mortuary customs that were not emotionally laden tended to conform to distribution patterns more than those that were "affect-laden customs" (Kroeber 1927: 308). This was in direct response to the work of W. H. R. Rivers who "argued that, because of the affect associated with death rites, mortuary customs would be adhered to with special tenacity" (Binford 1971: 10). Kroeber is important in this discussion as he was one of the first scholars to posit that not all customs and rituals followed the same type of patterns but that some may be of more utility for studying cultural customs than others. Burial customs, according to Kroeber, while they could occasionally display unstable histories, were of great utility when studying a culture (Binford 1971: 10). According to Binford (1971: 11), there are three reasons why a society might practice more than one type of mortuary ritual:

"1. The limiting effects of the environment, obtaining at the time of death, on the free exercise of all forms of body disposal.
2. Mutual effects of intersocietal contact in producing amalgamations or replacements of ritual forms.
3. The characteristics recognized as relevant to the relationships either severed or established at death between the deceased and the remaining members of society" (Binford 1971: 11)

One or more of these three principles could be at work in the differences between the MCPFC burials and those of the rest of the Milwaukee County population. One of the hypotheses that this dissertation addresses is that there is a difference in the material culture found in the burials of those individuals exhibiting signs of disease prior to their death. In both of these scenarios, one of the more likely factors at play is Binford's third principle (1971: 11). In the example of the MCPFC, some of these relationships may have been previously severed when the individuals who lived at the MCPF were admitted, and some may have been severed at their death. Radcliffe-Brown (1922: 148) wrote that “customs vary according to the social position of the deceased…There is, then, a close correspondence between the manner of burial and the social value of the person buried” (Radcliffe-Brown 1922: 148). The people interred in the MCPFC would have been influenced by the popular customs of the time, including the Beautification of Death movement, but their social standing would have prevented them from having the burial that they desired.

The idea of post-mortem agency, that the dead are actors with whom the living can interact, serves in this discussion to remind us that the dead still have agency and can influence our lives and our interpretation of their lives (Arnold 2014: 528). This also harkens back to Binford (1971: 11) and the third principle which is discussed in the above paragraph. Upon the death of a person, some relationships are going to be severed and others established (Binford 1971: 11). No individual, living or dead, is without the ability to influence and perform their own story. Rathje and McGuire (1982: 1) quote an English priest, as follows: “At the beginning we were all created equal. It is the tyranny of perverse men which has caused servitude to arise, in spite of God’s law”. To functionalists, the maintenance of this stratification is what gives society order. Agency theory, however, provides a counter to both of these deterministic views (Dornan 2002: 304). Neither are the wealthy determined to act as the lords of the poor, nor are the masses determined to rise up above the them, as Marxist theory holds (Dornan 2002: 304). The basis of agency theory is the idea that people, both the living and the dead, are not uniform players, but actively play a role in forming their realities (Dornan 2002: 304).

The stigmatization of living with a disease, particularly a pathogenic and highly infectious one, is going to inform the burial environment far more than the skeleton left behind by way of those that buried it (Schug 2016: 3). This stigmatization will also take the story further out of the hands of the deceased and put it into those that buried them. The mourners and the people performing the burial compel the individual who has died to become more fully dead by way of the burial rituals (Arnold 2014: 524). The mourners, or the people performing the burial, are also the ones deciding on how to bury the dead based on how their life was lived and how it ended. The process of burial and the idea of the spirit leaving the body differ from on culture to another, but the overall goal is for a certain ritual to have been performed which allows the deceased to become part of the dead and no longer one of the living (Schwartz 2000). This action does not prevent the dead from interacting with the living, however. Agency of action is ascribed both to the deceased and to the living. While the living are making the decisions regarding the dead and are often making decisions which heavily influence the way that the dead will be remembered, the dead themselves have a presence which cannot be denied. Years after the last grave markers were bulldozed and Milwaukee County stopped talking about its former Poor Farm Cemetery, the dead of the MCPFC found a way to come back into our lives.

The othering process

An article from the Milwaukee Journal from January 3rd, 1905, tells the story of a local man who ended up going to see a family in one of the poorer parts of the city. The reporter writes about how the father was in the House of Corrections for wife beating, and how the mother and eight children were living in a single room house with two beds. The children were between the ages of 2 and 16 and only the 14-year-old boy had a job. The family, he writes, was starving and "destitute". Despite this, he finishes his article on a cheerful note, writing that the family for all of their troubles seemed quite happy. To me, this image of a well-to-do citizen dropping by the house of the destitute and declaring them quite happy is an excellent example of what Foucault called the "othering" process (Foucault 1988). With the end result of this othering process being stigma (Schug 2016: 8).

Stories like this also excellently illustrate the ways in which the dead come back to interact with the living. While this story illustrates the way a poor Milwaukee family was "othered" by the gentleman who visited them and how they were further stigmatized by having their lives written about in the Milwaukee Journal, it should also be noted that the fact that their story has survived and is being written about in 2019 has its own sort of power. It is highly likely that those nine people have all died by now, or that at least the majority of them have. Their story still interacts with us not only in a historical way, but also by bringing to light current political issues that stem from the othering of people and families today. This story may have been written one hundred and fourteen years ago, but this it could just as easily have come from a current newspaper report of a politician visiting Puerto Rico after the 2018 hurricane and declaring that no catastrophe had occurred (New York Times Online, September 11th, 2018).

Foucault's thesis was that in order to understand the othering process, the "zero-point" had to be examined, the point just before illness began to diverge from non-illness (Foucault 1988, Schug 2016: 8). The problem with applying this type of analysis to tuberculosis is that the disease pre-dates written records by millennia (Daniels 2006). Schug (2016) applied this method to her study of leprosy based on records available for a leper hospital cemetery that dated to 1920-1925 in the city of Harrapa in South Asia. Leprosy, also a *Mycobacterium* species, presents much more subtly than tuberculosis does and does not have the power to cause immediate death. Schug (2016: 8) was able to trace back to this "zero-point" of Foucault's by observing individuals before the symptoms of leprosy began to show themselves. In the course of her work she found that although the isolation of those infected was othering and created stigma, the people themselves were buried similarly to the non-affected (Schug 2016: 8). The juxtaposition of the isolation in life and the burial within a community suggest several opposing viewpoints regarding the agency of the infected. Schug (2016: 1) writes that this isolation:

> "could be perceived as an opportunity for an enhanced degree of individual agency, as individuals with leprosy may take on a new existence free from expectations, norms, and traditions. However, social stigma is often deeply internalized" (Schug 2016: 1)

Muirdale, the tuberculosis sanitarium at the MCPF, had both a traditional hospital and a number of more comfortable cabins for people who were not expected to die from the disease and who did not submit to the designation of "pauper" in order to get affordable treatment. These cabins, and the higher socio-economic status of those who inhabited them, could have allowed the residents of Muirdale some degree of agency, in a way that was similar to leprosy sanitariums. The difference was that while tuberculosis was often deadly and could not be cured fully before antibiotics, a person could recover from it, whereas the diagnosis of leprosy was for life. However, while the isolation of tuberculosis patients was in some ways rational in that it protected the public from a highly contagious disease, the process which Schug (2016) describes was not biologically rational, as leprosy is rare and difficult to catch.

As Schug (2016: 1) writes, this othering process categorically occurs to the diseased during life, but does not always affect them in death. This gives the deceased who were diseased in life a certain amount of anonymity and potential agency if their burials do not represent any sort of othering process that they were subject to while alive. If the palaeopathology of the skeletal remains shows evidence of disease, they are both more likely to have their lives correctly interpreted post-mortem, but are also more likely to be assigned to another category and thus "othered" once again. If the bones of the deceased show evidence of disease and their burials are no different from the others in the same cemetery, this could obscure some of the suffering they experienced in their lives.

The archaeology of suffering

The people who were buried at the Milwaukee County Poor Farm Cemetery were no strangers to suffering. Early accounts of life at the Poor Farm paint a picture of sub-par housing, cold winters, and general neglect (Milligan 2010). An article from the Milwaukee Daily Sentinel dated January 7th, 1874 reports that conditions in the poorhouse had improved from what they had been three years prior, in 1871. The conditions in 1871 were described as "poor bread – totally unfit for the sick, miserable poor and filthy beds, insufficient clothing, bad ventilation, no water for cleanliness, and a shocking state of insecurity for the insane" (Milwaukee Daily Sentinel January 7th, 1874). In a Milwaukee Daily Sentinel article dated twelve months later, on December 8th, 1874, the Local Brevities section states that a meeting will take place that night in which a Mrs. Lynde will propose "the separation of the insane department from the poor farm" (Milwaukee Daily Sentinel December 8th, 1874).

By 1915 when the new tuberculosis sanitarium was built, conditions had improved. The people who either lived at the Poor Farm or who ended up being buried in the cemetery were the poor of Milwaukee and mostly immigrants without family in the area (Drew 2018: 150). The register of burials for the cemetery lists the occupations of the interred, with "laborer" being one of the most common occupations for men, and "housekeeper" for women who had an occupation listed (Richards 1997: 124). It was not until 1911 that Wisconsin introduced labor programs for the protection of workers, and began to relate safety to effectiveness. It was the effectiveness argument that finally persuaded employers to go along with the legislation. However, like the programs for the control of tuberculosis, 1911 did not magically see changes regarding safety in factories, and it was often the employees who couldn't speak or read English that were the most affected by the slowly changing policies (Korman 1967: 610).

As well as the physical pains that added to their suffering, it is important to remember that the people who lived at the MCPF Complex were institutionalized. The Milwaukee County Poor Farm began as an indoor relief project to provide housing for the poor of Milwaukee County (Richards et al. 2016: 229). What began as an Alms House in 1843 became the County Home for Children (1917), The County Infirmary (1917), the County Hospital (1860), the County Hospital for the Mentally Diseased (1917), the Milwaukee County Asylum for Mental Disease (1917), the Blue Mound Preventorium (1921), Muirdale Sanatorium (1915), and the Dispensary-Emergency Hospital (1930). As Klips (1980) wrote, "the public assistance system was the City's first line of defense against the threat of social disruption by the lower classes".

The goal of poor farms and almshouses was to turn the useless into the useful, and that creates a unique brand of suffering when the useless are living people (Klips 1980). A lot of the critiques of the initial almshouse at the MCPF was the integration of the insane and the criminal with the sick and the poor. The implication was that there was a "good" type of person to give aid to and that they should be separated from the "bad" sort of person who also needed aid. This created a class system within the lowest of the lower class and made further rungs to place people on and judge them worthy. For the people trapped within this system, the oppression of the labels themselves created their own type of suffering (Klips 1980). Often treated as if they were too uneducated to be able to understand where they stood in society, the poor and the sick were used as examples of middle- and upper-class charity more than they were allowed to have their own lives and agency.

Giddens (1979) attempts to bridge the theory of agency with the real social constraints under which people lived. He writes (1979: 150) that “human beings are neither to be treated as passive objects, nor as wholly free subjects”. Agency theory according to Giddens (1979) placed people in the role of habituated and reflexive actors who were constrained by circumstances and habits, but who were also able to consciously reflect on their actions and what their actions meant (Dornan 2002: 307). “This conceptualization of structure as the result of ongoing social relationships and interactions leaves room for change over time in those structures as individual practices are altered” (Dornan 2002: 307-308). This is an important distinction from the structural/functionalist theories in which agency is stripped in favor of determinism. At the same time that Giddens leaves room for individual agency, he acknowledges the habits and structures already in place to which people grow accustomed (Giddens 1979: 150).

Pollock (2016: 736) argues for a new methodology for studying the archaeology of suffering. Pollock (2016: 736) argues that “from the distanced abstractions of processual approaches to an emphasis on agency as empowering to today’s concerns with networks, materiality, and symmetry, [archaeology leaves] little place for hierarchical relations between individual subjects and oppressive contexts that produce suffering”. The people who were buried at the MCPFC not only experienced individual suffering, but also the “oppressive contexts” of the State and of their station in society. We need to connect the stories of real people, whether from historical or ethnographic sources or from what can be gleaned from a grave, to the condition of the State at the time and the oppressive constraints that were placed upon them. To avoid being like the man who walked into the one-room house of a family of nine and concluded that they were happy despite their many troubles, archaeologists need to be careful to not only focus on the positive aspects of individual agency while losing their focus on the subject of suffering (Pollock 2016: 726).

In some ways, Pollock (2016: 727) argues, this idea of the archaeology of suffering is at times directly at odds with post-mortem agency. While post-mortem agency lets the individual be their own actor and suggests that the dead can influence the living, the archaeology of suffering places more emphasis on the social structures that people were forced into during life and how those structures shaped their lives and deaths. In her study of immigrants to the UK with terminal illnesses, Gunaratnam (2012: 113) tells the story of a man named Ibrahim who wanted to be transported back to Ghana after his death. His one wish for his remains was to be buried back where he came from. Due to monetary limitations, however, his family could not afford to transport his body back to Ghana and ended up burying him in the UK. Ibrahim wanted to exhibit a certain amount of post-mortem agency in his request of what to do with his physical remains. His family, however, because of the socio-economic limitations placed upon them, were not able to honor his request. Not only did they suffer monetarily after losing Ibrahim, but they then suffered guilt over their inability to honor his wishes (Gunaratnam 2012: 114). Gunaratnam (2012: 115) writes that this adds up to the "total pain" of the situation. We must take into account not only the pain that Ibrahim suffered while dying a painful death, but also the loss of a certain type of agency of his family both in their inability to bury him in Ghana and in their decrease in socio-economic status.

Archaeologically, these sorts of factors may or may not be visible. Gunaratnam (2012: 109) defines total pain as something that "interpolates, and at times creolizes, physical, social, psychological and spiritual pain. It also gives recognition to pain that is accrued over a lifetime". While Gunaratnam studies the total pain of living and dying individuals, Pollock (2016: 727) believes this principle can be applied to the deceased as well. Applied to the people of the MCPFC, the pain that had accrued over their lifetimes continued to accrue after their deaths. If the dead are actors that can manipulate us and can be manipulated by us, we must consider that we are potentially adding to their total pain. I believe that if we study the dead in a way that allows for potential individual agency while providing space for the suffering that they went through as individuals and as people living oppressed lives, we can find a balance between the romanticizing of history and the stigmatization of the dead.

Chapter 3

Milwaukee County and Infectious Disease

"We have yet to write the history of that other form of madness, by which men, in an act of sovereign reason, confine their neighbors"

-Foucault

Disease at the turn of the 20th century in Milwaukee

In Milwaukee County, Wisconsin, in the early 20th century, tuberculosis killed between ten and fourteen percent of the population, the most of any disease at the time (Leavitt 1982: 28). 1882 saw a peak, with deaths from tuberculosis hitting 14.1%, the highest percentage reached between 1870 and 1920 (Leavitt 1982: 28). The endemic nature of the disease in Milwaukee, and in larger contemporary cities, meant that although tuberculosis was a leading cause of death, it was one that citizens were able to anticipate and grow accustomed to, and thus did not become a public health priority. The push for public policies that would control the spread of the disease was not as rapid or as highly prioritized as policies that controlled more epidemic diseases such as cholera or smallpox (Leavitt 1982: 76). As the population of Milwaukee grew, so did the prevalence of tuberculosis and other diseases that thrive in urban cities. Spread by air droplets when an infected person coughs, tuberculosis runs rampant through any city where people are living in close quarters. In the case of Milwaukee in the early 1900s, this meant that the immigrant population was most directly affected.

Milwaukee was quickly urbanizing and was an attractive hub for those looking for work (Leavitt 1982: 22). By 1850, sixty-four percent of the population of Milwaukee had been born abroad (Milligan 2010: 15). Crowded into unheated housing with several other people or families and forced to work long hours of hard labor, immigrants were set up to lose. Figure 3.1 is a photograph taken between 1905 and 1909 that shows an immigrant family departing Ellis Island to their final destination of Milwaukee, WI. By 1907, more than 10,000 such immigrants walked through Ellis Island daily (Markel and Stern 2002: 1317). While the newly immigrated provided a lot of the services that were needed to keep the city growing, anti-immigrant sentiment was particularly high during this time period (Markel and Stern 2002: 1318).

Figure 3.1 A family at Ellis Island on their way to Milwaukee, circa 1905-1909 (James Blair Murdoch Photograph Collection)

The Immigration Act of 1891 stated that a person could not be admitted to the country if "suffering from a loathsome or dangerous contagious disease" (Markel and Stern 2002: 1319). This meant that potential immigration into the country was defined by health and pathology, and exclusion and deportation were very real possibilities based upon the port inspections by the U.S. Public Health Service (USPHS). While the intention of this act was to protect the country's citizens from diseases that they had not developed immunity to yet, the reality of it was that it stigmatized the newly immigrated as potential carriers for dangerous diseases. Kraut (1994) traces back the bias against immigrants in our country to these early laws. The Immigration Act and the resulting inspections by the USPHS promoted the idea that foreigners were dangerous, disease-ridden, and something to be fought against as they tried to gain entry into our country (Kraut 1994). The decision of whether or not to let a person enter the U.S. was supported by the "loathsome or dangerous contagious disease" verbiage, but at the time the medical tools available to USPHS officials could not conclusively provide a specific diagnosis. Consequently "diseased" became synonymous with being dirty, extreme poverty, or holding any number of religious or political beliefs that the USPHS decided were unworthy (Markel and Stern 2002: 1319). This became more relevant as the years went on. In the 1910s, public health officials began excluding people of "poor physique", which oftentimes meant those of Eastern Europe origin, including Jews (Markel and Stern 2002: 1319).

Tuberculosis, of course, was one of the diseases that public health officials were trying to keep out of US ports of entry. This was nearly impossible, as it was so prevalent during those years that even if a person was no showing symptoms, it was highly likely that they had the latent disease (Daniels 2006). When infected with *Mycobacterium tuberculosis*, a person does not always exhibit symptoms, but can hold the bacterium in reservoir (Sridhar 2011: 1021). Part of why this occurs is due to the ability of *M. tuberculosis* to avoid detection in the body by inhibiting the lytic properties of macrophages and by avoiding intracellular destruction (Sridhar 2011: 1022). This can occur in two ways. In the first case, a person can become infected with tuberculosis and show active symptoms which then decline, but instead of actually clearing the disease, the bacteria will still be present in the body. In the second case, a person can come into contact with active tuberculosis but their immune system is strong enough to suppress the symptoms. A person can stay in a stage of latent tuberculosis infection for years and never go into an active disease phase. The second example, where a person comes into contact with tuberculosis and immediately acquire latent infection, is more common for healthy immunocompetent adults. It is usually people at the extremes of the age range, or those who are in a state of poor health to begin with that will immediately show symptoms of active disease (Sridhar 2011:1022).

Though tuberculosis was not a new disease during the later 19th century, the concept of it as infectious was new, due to the work of Robert Koch who, identifying the *Mycobacterium tuberculosis* bacillus (Buikstra and Cook 1980:438). Prior to Koch identifying the bacterium in the 1880s, tuberculosis had been thought to be a hereditary disorder. When it was discovered that this was not the case, a kind of panic set in, and the efforts to quarantine those suffering from the disease increased (Denoyelles 2016:349). The immigrants who made it into the country despite these challenges and found themselves living in Milwaukee County, they unfortunately found that the anti-immigrant sentiment was not limited to the USPHS officials at Ellis Island (Markel and Stern 2002: 1319). While tuberculosis, as well as any other infectious disease, respects no boundaries of age, sex, ethnicity, or socio-economic status, for the newly immigrated who were living in tight quarters with no access to health care and with terrible working conditions, tuberculosis was more common than in the general population (Reitmanova and Gustafson 2012: 404, Denoyelles 2016: 350).

For anyone, but particularly immigrants, who found themselves at the Milwaukee County Hospital and the other buildings that made up the Milwaukee County Poor Farm, all these factors combined with abject poverty and complete loss of social status only made a bad situation worse. Tuberculosis Sanitariums became common throughout the country, including Muirdale in

Milwaukee County, as a safe place for tuberculosis patients to rehabilitate away from the general population (Leavitt 1982: 270) (Figure 3.2).

Figure 3.2. Muirdale Sanitarium (Stolder 1994:287)

When tuberculosis is in its active disease state, it causes respiratory distress, including coughing, wheezing, bloody sputum, and chest pain, as well as fatigue, weight loss, and general weakening of the body (Holloway et al. 2013: 1). Death from the disease usually comes in the form of pneumonia, wherein the lungs are too full of fluid and bacteria to keep functioning properly (Daniels 2006). Figure 3.3 shows a photograph from November 20th, 1921 of two people standing by a patient's bedside at Muirdale Sanitarium.

Figure 3.3 Two people stand by a patient's bedside at Muirdale Sanitarium on November 20^{th}, 1921 (James Blair Murdoch Photograph Collection)

Though less common, neurological symptoms are also possible, especially when Pott's disease is present. Due to the compression of the spinal nerves and the spinal cord caused by the angulation of the vertebrae and the deterioration of the intervertebral disks, lack of sensation, loss of movement, and pain are all possible symptoms (Kumar 2016: 553). This could cause what is sometimes referred to as Pott's paraplegia (Kumar 2016: 551). Compression paraplegia oftentimes first appears as a loss of motor function, due to the location of the motor fibers in conjunction with the spinal cord. When the tubercular lesions are present on the anterior aspects of the vertebrae, which is most common, the pressure would first be exerted upon the cerebrospinal fluid. The buildup of this compression and pressure from the anterior aspects leads to displacement of the anterior motor fibers. Drainage of this fluid can alleviate this pressure, though it cannot reverse the effects entirely (Kumar 2016: 553).

Treatment for tuberculosis at the time was typically a combination of fresh air, sunshine, rest, and isolation. Thus, the tuberculosis sanitarium was created. A less common method of treatment was surgery (Holloway et al. 2013: 6). While surgery was expensive and unusual, if the disease progressed into Pott's Disease, one option was to perform a procedure invented by Dr. Fred H. Albee in 1909 in which the intervertebral joints were immobilized in order to allow ankylosis (Holloway et al. 2013: 2). Oftentimes during this procedure, a bone graft taken from the patient's own tibia was used to allow bracing of the joints (Holloway et al. 2013). This had the added benefit of grafting additional blood vessels into the area and allowing blood to flow to the severely damaged bone (Holloway et al. 2013: 2). The drawbacks of surgery were numerous. The risk of infection from surgery in a pre-antibiotic era were particularly abundant and the outcomes could be especially grim (Figure 3.4).

Figure 3.4. A drawing from Kumar (2016:554) depicting an experience of the author in which a patient with Pott's paraplegia that was willing to pay the surgeon's fees if only to avoid surgery.

During the last quarter of the 19th century, the health profile of Milwaukee County citizens was typical for a large industrial city of the time. The last major cholera outbreak had occurred in 1854 and a small pox outbreak had occurred in 1869 (Leavitt 1982: 54, Chan et al. 2013). A permanent Health Department was created in 1869, making Milwaukee one of the first cities in America with a specialized Health Department. Despite this, the first ten years after the department's creation saw slow change, most of which was focused on policies for the prevention of smallpox, and was characterized by a lot of disagreement between the Public Health Board, the Milwaukee government, and the citizens of Milwaukee regarding best health practices (Leavitt 1982: 86). The Public Health Department focused its early efforts on encouraging smallpox vaccination and on isolating sufferers in the pest house on the west side of the city, the latter of these efforts meeting with significant backlash due to the inability to work while confined, the social implications of having to be quarantined, and the high death rate once forced into the pest house (Leavitt 1982: 86). The German immigrant population was particularly resistant to the idea of vaccination and this contributed to the already growing division between the German immigrants and the rest of Milwaukee County (Leavitt 1982: 83). In her book, *The Healthiest City: Milwaukee and the Politics of Health Reform*, Judith Leavitt shares the story of a young boy who was diagnosed with small pox. The community grew so angry about the city government's attempt to remove the boy from his house and place him under quarantine at the pest house, that a mob of some 2,000 people gathered and refused the county health officials access to the boy and his family. Such were the feelings of the community at the time regarding the city's and county's efforts to treat, or isolate, those who were infected with infectious diseases (Leavitt 1982: 106).

Contributing to the already tense atmosphere surrounding mandatory public health procedures, in 1878 the head of the Health Department began a crusade against tuberculosis that met with a significant backlash. Like many public health crusades today, there were also people who directly opposed the legislation and implementation of city-wide health procedures for their own benefit. This began the era in Milwaukee County that is referred to as the Milk Wars, due to the opposition that came from the dairy industry (Leavitt 1982: 157).

Mycobacterium tuberculosis and other members of the *Mycobacterium tuberculosis* Complex (MTBC), most notably *Mycobacterium bovis,* can infect cattle. This occurs particularly frequently in unsanitary conditions (Connolly 2008). Both the city of Milwaukee and the surrounding farm land relied heavily on the dairy and cattle industry. While farms flourished in the countryside, animal husbandry was not restricted the outlying areas and several dairies were set up in the city of Milwaukee proper (Leavitt 1982). The conditions of Milwaukee dairies in 1878 were particularly unsanitary (Charaus 2010: 97, Leavitt 1982: 157). Leavitt (1982) describes public health and newspaper reports of those years describing these urban farms as littered with animal waste and dead animals, moreover, the animals that were used at the dairy were all in close proximity in small yards behind city dwellings. The milk delivery system at the time was a large jug that a person would cart to houses by horse into which the individual home owners would dip their previously used milk jugs by hand (Leavitt 1982: 157). For thirty years, between 1878 and 1908, the Health Department and its various directors had slowly passed laws regulating the conditions of dairy cows and the practices of milk handling, in the face of significant public backlash.

It was not until 1908 that the city finally passed a tuberculosis campaign for disease prevention, mostly aimed at the dairy industry, but the campaign saw little success for the next five years. The plan that the Health Department proposed in 1911 required mandatory reporting of tuberculosis cases as well as home health care by trained nurses (Charaus 2010: 170). 1913 saw the passing of a law that required tuberculosis testing for all dairy cows and by 1916 both testing and pasteurization of milk was required (Leavitt 1982: 186) (Figure 3.5). During this long interval of political debate, tuberculosis continued to flourish in Milwaukee County.

FARMERS THREATEN TO BOYCOTT MILWAUKEE

Country Merchants Assert They Will Be Affected if Threat Is Carried Out in Milk War.

Because of the enforcement of the tuberculin test ordinance, Milwaukee faces a boycott from farmers in the vicinity, and from country grocers, who declare they will buy their goods in Chicago if such a boycott is declared.

This is the statement of John Reinders, grocer, Elm Grove, following a farmers' meeting in that place, Friday night.

"We do not want to buy in Chicago, but we will have to if the farmers decide to cut out Milwaukee and refuse to buy Milwaukee goods," said Mr. Reinders.

Figure 3.5. A 1914 article from the Milwaukee Journal regarding the Milk Wars between farmers and the Public Health commissioner.

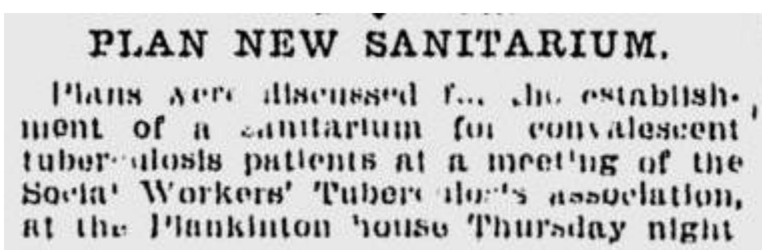
Between the years of 1911 and 1915, Milwaukee County reported that 27% of all cases of tuberculosis occurred in the poor areas of the city (Charaus 2010). Figure 3.7 shows an article from the Milwaukee Journal in 1911 that announces that the city of Milwaukee plans to open a hospital for the treatment of tuberculosis. Another article from the Milwaukee journal, Figure 3.8, shows the announcement on November 21st, 1915 announcing the opening of Muirdale.

Muirdale Sanitarium was built on the Milwaukee County Poor Farm Cemetery grounds. The poor farm, which started with the donation of a 160-acre farm from Hendrik Greg, a member of the Milwaukee County Board, was located in the Town of Wauwatosa, WI, approximately seven miles east of the city of Milwaukee (Richards et al. 2016: 11). Prior to 1852, the city of Milwaukee had been focused on out-door relief, which consisted of providing the poor with food, firewood, and temporary lodging (Richards 1997: 53). In November of 1852, the first twenty-four residents moved into the farm and Milwaukee County began its indoor relief project for the poor. Four years later, in 1856, Milwaukee County added a small school next to the main building for the purpose of educating the children who lived on the property (Richards et al. 2016: 11).

In 1860, the first County Hospital was constructed on the Poor Farm grounds (Richards 1997: 56). Prior to 1860, "the poor, the sick, the orphans, and the insane shared the same living quarters" (Milwaukee Sentinel: May 28, 1856 quoted in Richards 1997: 56). After numerous complaints about the conditions of the Poor Farm buildings, 1868 saw the construction of a new hospital on the grounds. This led to the separation of the sick from the rest of the Poor Farm inmates (Richards 1997: 60).

Prior to the opening of Muirdale, tuberculosis patients in the city of Milwaukee had the option of recuperating at the Blue Mound Sanatorium for Incipient Tuberculosis which was in operation between 1907 and 1921 (Richards et al. 2016: 15). Before the creation of the Blue Mound Sanatorium, tuberculosis patients were housed either in the hospital or in one of the other buildings that were part of the Poor Farm Complex. Figure 3.6 shows a picture taken prior to the construction of the Blue Mound Sanatorium when the tuberculosis pavilion was part of the Milwaukee Hospital for the Insane (James Blair Murdoch Photograph Collection). This picture shows one of the most common treatments for tuberculosis of the time: fresh air and the outdoors. Clearly visible are people sitting around the porch bundled in blankets against the Wisconsin chill, breathing in the cold air.

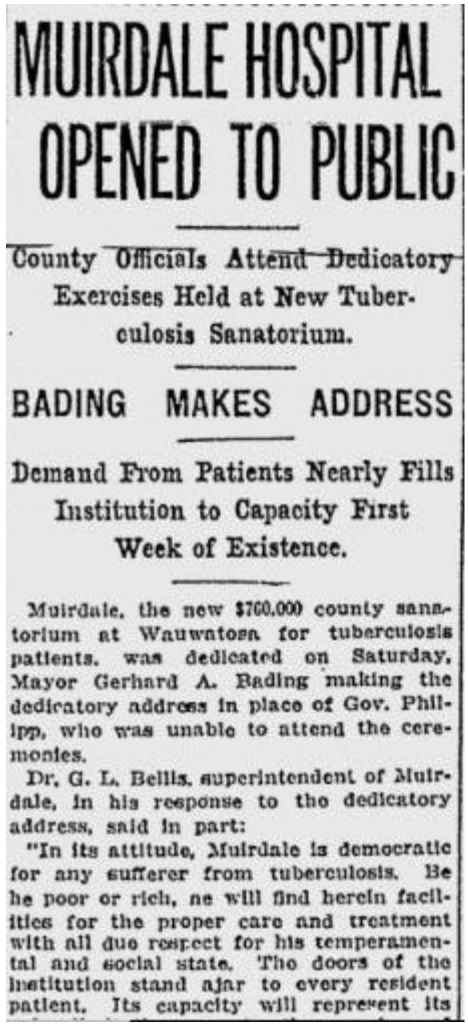
Figure 3.6. The Tuberculosis Pavilion at the Milwaukee Hospital for the Insane (James Blair Murdoch Photograph Collection)



PLAN NEW SANITARIUM.

Plans were discussed for the establishment of a sanitarium for convalescent tuberculosis patients at a meeting of the Social Workers' Tuberculosis association, at the Plankinton house Thursday night

Figure 3.7. Plans announcing the building of a tuberculosis hospital from the Milwaukee Journal in 1911.



MUIRDALE HOSPITAL OPENED TO PUBLIC

County Officials Attend Dedicatory Exercises Held at New Tuberculosis Sanatorium.

BADING MAKES ADDRESS

Demand From Patients Nearly Fills Institution to Capacity First Week of Existence.

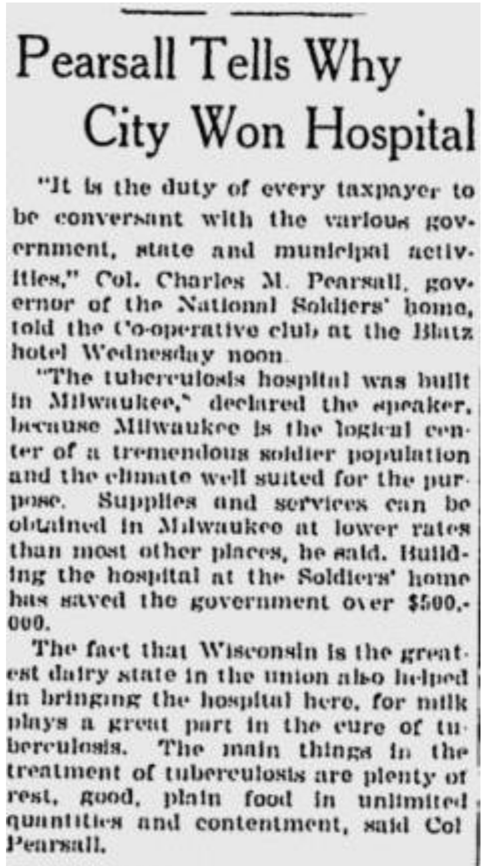
Muirdale, the new $700,000 county sanatorium at Wauwatosa for tuberculosis patients, was dedicated on Saturday, Mayor Gerhard A. Bading making the dedicatory address in place of Gov. Philipp, who was unable to attend the ceremonies.

Dr. G. L. Bellis, superintendent of Muirdale, in his response to the dedicatory address, said in part:

"In its attitude, Muirdale is democratic for any sufferer from tuberculosis. Be he poor or rich, ne will find herein facilities for the proper care and treatment with all due respect for his temperamental and social state. The doors of the institution stand ajar to every resident patient. Its capacity will represent its

Figure 3.8. A November 21st, 1915 article in the Milwaukee Journal announcing that Muirdale Sanitarium is open to the public.

An article from 1924 tells the story of how Milwaukee was able to secure funding for the construction of Muirdale, including, interestingly and ironically, the fact that the great state of Wisconsin has plenty of milk, which is known to play a part in the cure of tuberculosis (Figure 3.9).



Pearsall Tells Why City Won Hospital

"It is the duty of every taxpayer to be conversant with the various government, state and municipal activities," Col. Charles M. Pearsall, governor of the National Soldiers' home, told the Co-operative club at the Blatz hotel Wednesday noon.

"The tuberculosis hospital was built in Milwaukee," declared the speaker, because Milwaukee is the logical center of a tremendous soldier population and the climate well suited for the purpose. Supplies and services can be obtained in Milwaukee at lower rates than most other places, he said. Building the hospital at the Soldiers' home has saved the government over $500,000.

The fact that Wisconsin is the greatest dairy state in the union also helped in bringing the hospital here, for milk plays a great part in the cure of tuberculosis. The main things in the treatment of tuberculosis are plenty of rest, good, plain food in unlimited quantities and contentment, said Col Pearsall.

Figure 3.9. A July 16th, 1924 article from the Milwaukee Journal discussing the reasons for the construction of Muirdale.

Burial at the Milwaukee County Poor Farm Cemetery

Muirdale Sanitarium treated both the wealthy and the poor and accepted tuberculosis patients free of charge if they accepted the designation of "pauper" (Charaus 2010). Those with the designation of pauper were more likely to be buried in the MCPFC, as accepting this designation meant that they signed away their rights as private citizens and all of their worldly possessions (Crafer 1907: 21). According to Crafer (1907: 21), "Section 1505 (a), Ch. 136, Laws of 1899, provides that if at the time a person received poor relief, he or she possessed any property, the amount of the relief afforded shall be a valid claim against said person, and may be recovered in an action at law by the political unit granting the relief".

Few would accept being designated as paupers if they had any family in the area or the country, that could help rehabilitate them, or at the very least bury them. Burial in a pauper cemetery was considered an absolute last resort, and people were known to live in poverty in order to save for a proper church burial (Charaus 2010). Not only was the burial itself minimal, with a plain grave marker and burial in shrouds, but it was not assured that the grave would remain undisturbed. When Wisconsin had still been a territory, the original territory laws stipulated the necessity for "decent burial" for the poor (1838 Wis. Terr. Law 22). This did not, however, stipulate what was included in a decent burial (Drew 2018: 27). The Milwaukee County Rules and Regulations for the County Farm and Almshouse that were published in 1894 stipulated what constituted a proper burial, and how they were to be recorded. Rule 17 stated that "The superintendent shall keep a record of all pauper burials on the County Farm, file all burial permits, and place a painted and numbered head board at each grave, which grave shall, in no case, be less than six feet deep. The burial record shall specify the name of the deceased, date and cause of death, number of burial permit, and the number of the grave in which they were buried. It shall be the duty of the Superintendent to see that the cemetery is kept in decent order" (The Milwaukee County Rules and Regulations for the County Farm and Almshouse from Richards 1997: 78).

The first official record by Milwaukee County of a burial on the Poor Farm ground was in 1872, for the infant of Rosa Flymann (Richards et al. 2016: 18). This burial in 1872 was in the plot of land that would later be designated as Cemetery I (Drew 2018: 52). While Milwaukee County would not begin officially recording records of burials until 1882, with the creation of Cemetery II, Cemetery I was known to already have been in use by 1882 (Richards et al. 2016: 18). In addition to the burial of Rosa Flymann's infant child, the Milwaukee County Board of

Supervisors Proceedings in 1878 mentions a cemetery on the Poor Farm grounds (Richards et al. 2016: 18). Cemetery II, which was excavated in 1991/1992 and which includes individuals analyzed in this thesis, was established in 1882 and was in use until 1925. Two more cemeteries were established while the MCPF Complex was in operation, Cemetery III which opened in 1925, and Cemetery IV which is located closest to the Milwaukee County Hospital for the Acute Insane, and whose dates are unknown (Drew 2018: 32). The three remaining cemeteries, Cemeteries I, III, and IV, all remain undisturbed (Richards et al. 2016: 17).

In 1932, just seven years after Cemetery II ceased to be used, the grave markers were removed and a nurse's college was built in its place (Richards 1997: 41). While various construction and utility projects disturbed the burial grounds between 1932 and 1991, it was not until 1991 that graves were actually systematically excavated when the building of a new nurse's residence began. The 1991/1992 excavation of the Milwaukee County Poor Farm Cemetery by the cultural resource management firm Great Lakes Archaeological Research Center, Inc. (GLARC) uncovered 1,649 individuals from Cemetery II (Richards 1997: 274). Figure 3.10 depicts the location of the MCPFC cemeteries in the greater Milwaukee area in Wisconsin. Figure 3.11 provides the details of Cemetery II, excavated in 1991/1992 and again in 2013, as well as the remainder of the cemetery which is still intact beneath Doyne Avenue.

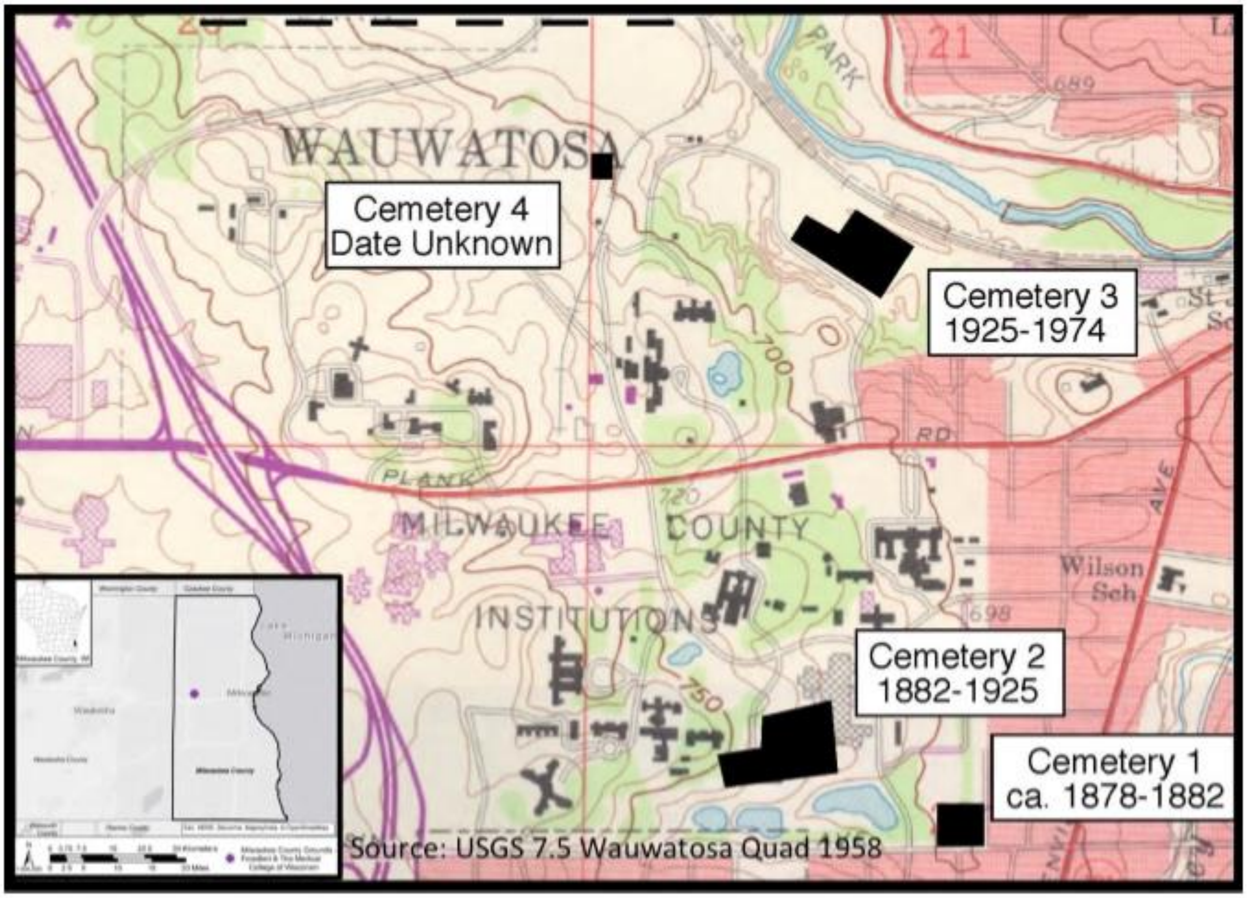


Figure 3.10. The Milwaukee County Poor Farm Cemetery in Wauwatosa, Wisconsin, located in the Greater Milwaukee Area (Richards et al. 2016).

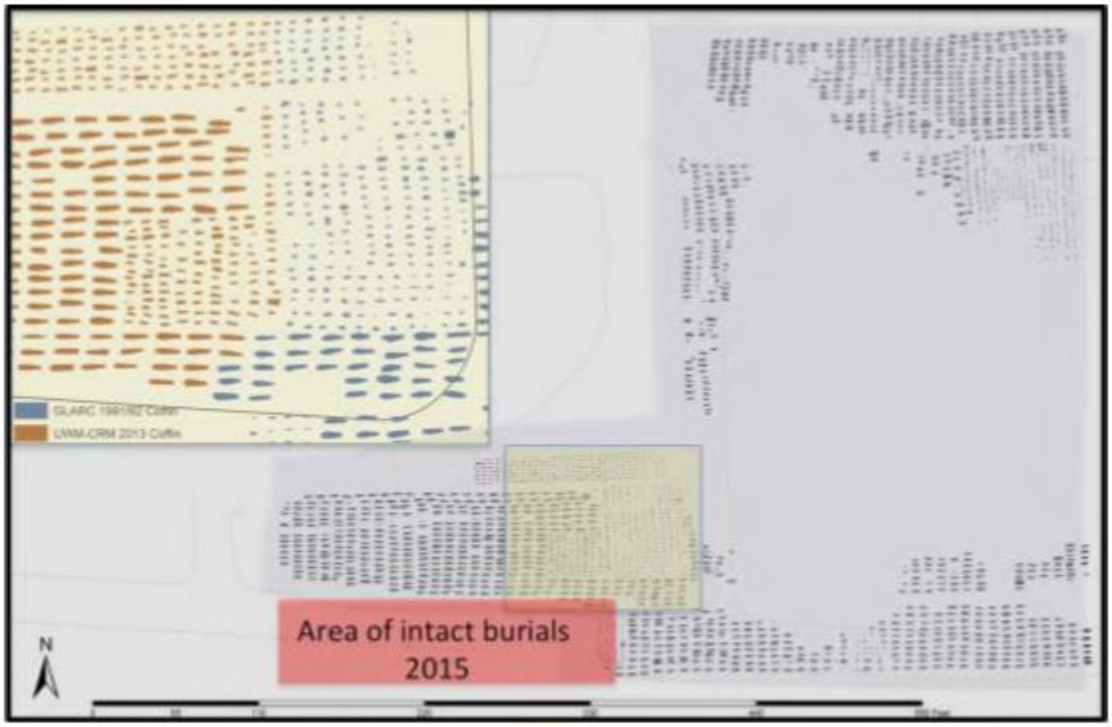


Figure 3.11. The excavations of the Milwaukee County Poor Farm Cemetery in Cemetery 2 in 1991/1992 and 2013, as well as the portion of the cemetery which is still covered (Richards et al. 2016).

While the Register of Burials from the Milwaukee County Poor Farm has survived, due to the lack of grave markers at the time of excavation and the lack of a map accompanying the Register of Burials, the vast majority of the individuals are still unidentified. The ongoing goal of the University of Wisconsin-Milwaukee MCPFC Project, which is curated by the UWM Archaeological Research Laboratory, is to identify as many individuals as possible and to restore and retain each individual's personhood.

Chapter 4

The Bioarchaeology of Respiratory Diseases

The challenge of all bioarchaeologists is how to interpret the anatomical changes that are left on a skeleton after death in a way that allows accurate and useful information to be gained. In the case of infectious diseases clinical observations and data are often available to help interpret what we are seeing post mortem. Modern study of tuberculosis, brucellosis, and pneumonias caused by *Streptococcus pneumoniae*, have revealed how these diseases move from the respiratory system into the adjacent bone. Pyogenic spondylodiscitis, infections of the vertebral bodies, originate from the haemopoietic tissues and travel from the vertebral bodies onto the intervertebral discs in adults (Miksic 2013). Haemopoietic tissues are those in which the precursors to blood cells are enmeshed (Miksic 2013). In children, the process of infection of the spine is usually reversed and the intervertebral discs are infected before the bony tissue (Miksic 2013). The spine is not always the site of bacterial osteomyelitis, however in the case of many respiratory infections, it is often one of the primary sites of infection. Due to the aforementioned mode of infection of the vertebral bodies via the haemopoietic tissues, the nearness of the lungs to the vertebrae can create a pathway from the respiratory infection to travel to the spine.

Bioarchaeology of tuberculosis

Tuberculosis in human remains has been studied for a long time in part because it is one of the only infectious diseases to move to the skeleton, and in part because of its long history with humans. The earliest case of identifiable osteological tuberculosis comes from Syria from remains which date between 8800 and 7600 BC (Witas et al. 2015: 1734). It is not a coincidence that this is right around the time of the earliest animal domestication (Witas et al. 2015: 1734). There is a long history of zoonotic transmission between *Mycobacterium* tuberculosis and animal hosts (Bos et al. 2014:494) Prior to this, the earliest known report of osteological tuberculosis came from Hershkovitz et al. (2008) from a Neolithic burial around 7000 BC. The link between animal domestication and these early cases of osteological tuberculosis is clearly important. One of the most interesting factors about the spread of tuberculosis spread is its unique ability to be found both in rural environments and large urban centers (Witas et al. 2015: 1734).

The coating of mycolic acid that surrounds the bacterium causes the DNA to preserve well over time in comparison to other bacteria. Tuberculosis spreads to the skeleton in 2 - 4% of cases, which, though a small percentage, is higher than for many other bacterial diseases (Raff et al. 2006). Infectious diseases have evolved along with their human hosts and understanding their prevalence within a population can inform researchers of the living conditions and health of the society in question. This holds particularly true in the case of tuberculosis where, as discussed in Chapter 3, the living conditions of the population and the prevalence of the disease go hand in hand.

One of the hallmark indicators of tuberculosis in skeletal remains is the “destruction of the lower thoracic and/or lumbar vertebral bodies leading to spinal collapse and kyphosis” (Roberts and Buikstra 1980, Buikstra 2009). This “very typical ventral collapse of the vertebral body leading to a more or less severe angulation of the vertebral column” is more commonly seen as the end stage of osseous tuberculosis (Nerlich and Losch 2009). Clinically, this type of vertebral collapse of the thoracic spine is referred to as Pott’s Disease. Figure 4.1 shows the classic kyphosis caused by Pott’s disease in an autopsy case of a 35-year-old male from Holloway et al. (2013).

Figure 4.1. Typical angular collapse of the spine caused by tuberculosis infection. Autopsy of a 35-year-old male (Holloway et al. 2013: 3).

The problem is that this complete vertebral collapse is far rarer than finding subtle indicators, which are easily confused with other diseases. When the anterior aspect of the vertebral bodies is affected, this can look strikingly similar to a number of other diseases, including "brucellosis, fungal infections, septic arthritis, neoplastic disease, and osteoporosis" as well as "blastomycosis, typhoid spine, healed vertebral fractures, septic arthritis, malignant bone tumors, Paget's disease, and ankylosing spondylitis" (Wilbur et al. 2009, Milligan 2010). One of the MCPFC burials, Burial 1009, showed lesions consistent with tuberculosis, is shown in Figure 4.2.

Figure 4.2. MCPFC Burial 1009 vertebra, a middle-aged male showing complete lytic destruction of the vertebral body.

Osteoarthritis occurs in high numbers in the MCPFC collection, and therefore the potential for confusing it with tuberculosis is high (Milligan 2010). Some of the infections that present like tuberculosis are found within the MCPFC, including blastomycosis, brucellosis, and typhoid spine, according to the Register of Burials (Milligan 2010).

The ribs are considered a secondary site of osseous tuberculosis infection, though lesions on the ribs may be caused by an assortment of severe immune responses that occur in the lungs (Roberts and Buikstra 2008). Tuberculosis spreads through a central focus, something that can help differentiate it from other diseases, such as treponematosis, another infectious disease that can present osteologically (Ortner 2011: 4). Rib lesions are therefore insufficient for identifying MTB, even with the addition of suspected tuberculosis lesions in the vertebrae, due to the high probability that different localities of lesions were caused by different organisms (Raff et al. 2006). Tuberculosis, whether latent or recently acquired, has been shown to show up in conjunction with other respiratory infections, including influenza and pneumonia (Noymer 2009: B40). Tuberculosis has also been known to infect the weight bearing joints and the skull, most likely due to a systemic spread of the disease through the blood stream, something that is at odds with the theory of unifocal spread (Nerlich and Losch 2009, Ortner 2011: 4). The ankylosing of weight bearing joints and lesions present on the skull can be found in association with other diseases that present similarly to tuberculosis, most notably osteoarthritis, brucellosis, and Paget's disease (Nerlich and Losch 2009, Raff et al. 2006).

Tuberculosis spreads in a linear fashion from the site of the infection outwards. Unlike treponemal diseases which show clustering of lesions on the limbs and places where there is less fat or muscle between bone and skin, tuberculosis primarily affects and infects the spine (Buikstra and Cook 1980). The most common vertebrae to show either lytic lesions, which destroy the healthy bone, tissue or osteophytic lesions, in which abnormal bone growth is added to the existing bone, are the thoracic and the lumbar (Nerlich and Losch 2009). Vertebral lesions caused by tuberculosis are often found on the body of the vertebrae and are asymmetrical in presentation, meaning that they are not diffuse across the width of the body (Nerlich and Losch 2009). Ribs which have been affected show lesions on the posterior side of the rib, the surface which is most closely spatially related to the lungs.

There are problems associated with attempting to infer tuberculosis infection using only skeletal remains, including the aforementioned fact that the spread to bone is uncommon. Due to the nature of how tuberculosis affects skeletal tissue, it can present a similar appearance to a number of other diseases. A subset of anthropologists, however, believes that with the correct blend of technique and historical data, it is possible to determine whether an individual suffered from tuberculosis in their lifetime, and to estimate prevalence of population infection as a whole (Roberts and Buikstra 2008, Roberts and Buikstra 2012). At the forefront of this field, Buikstra, Roberts, Stone, and Wilbur have published prolifically on the identification of tuberculosis in human skeletal remains. Stone and Wilbur argued in their 2012 contribution to Buikstra and

Roberts' paleopathological anthology that the destruction of bone for molecular biological studies is not warranted when tuberculosis can be successfully identified from osteological evidence alone (Roberts and Buikstra 2008, Roberts and Buikstra 2012, Wilbur et al. 2009). Wilbur et al stress that in order for a purely osteological analysis of tuberculosis to be successful the analysis must be rigorous and thorough (Wilbur et al. 2009).

Buikstra and Cook (1980: 442) provide one of the most useful and earliest studies of what to expect when looking for tuberculosis in skeletal remains. They describe how the pattern of infection is one of the key ways of differentiating between tuberculosis and other infectious diseases of the skeleton. Unlike syphilis, osteoarthritis and pyogenic osteomyelitis, the surface lesions of tuberculosis are asymmetrical (Buikstra and Cook 1980: 442). Their work also confirms the importance of knowing the age of the individuals when looking for osteological lesions. Certain diseases, tuberculosis among them, will not show up skeletally in young children. The disease will not have had time to move to the skeleton to produce visible lesions in people who die young from the disease (Buikstra and Cook 1980: 443).

Stone et al. (2009: 68) also emphasizes the use of patterns when looking for evidence of tuberculosis in skeletal remains. Just as Buikstra and Cook (1980) noted the importance of age when looking for tubercular lesions, Stone et al. (2009: 68) discusses the reason why this is important. *Mycobacterium tuberculosis* tends to migrate to and localize within the hemopoietic tissues. Hemopoietic tissues are those from which progenitor blood cells arise (Stone et al. 2009: 68). These tissues are more widely distributed within juveniles than within adults, which is why tuberculosis in juvenile skeletons can present very different than within adult remains. Stone et al. (2009: 68), however, does not suggest that tuberculosis of the skeleton does not have time to occur in children, but argues that due to the diffuse nature of hemopoietic tissues throughout the skeleton it just appears differently, and presents more similarly to other juvenile illnesses. Stone et al. (2009: 68) writes that "TB in children may even cause destructive, expansive lesions within the tubular bones of the hands and feet (*spina ventosa*), the skull, and other flat bones of the body".

Wilbur et al. (2009) sums up the challenges of working with skeletal tuberculosis succinctly, when she writes "The critical issue when considering skeletal evidence for TB is to be aware that there are no pathognomonic lesions" (Wilbur et al. 2009: 1991). This issue of pathognomonic lesions is an important one to discuss. A symptom or a gross anatomy feature which is pathognomonic for a particular disease means that it is specific to that disease. Tuberculosis in skeletal remains does not have any of these indicators. Instead, we are left looking for lesions and patterns that are consistent with the disease. Wilbur et al. (2009: 1991) follows Buikstra and Cook (1980) in suggesting, that typically tuberculosis will present in the lower thoracic vertebrae and the lumbar vertebrae and the lesions will be concentrated in the central part of the vertebral body, most commonly on the anterior aspect (Wilbur et al. 2009: 1991). Lysis is more common than new growth of the bone, particularly if the collapse of vertebral bodies presents in a way that would cause kyphosis of the spine (Wilbur et al. 2009: 1991). Lesions on the joint surfaces of the hip and the knee are of secondary importance, and abnormal bone formation on the visceral surfaces of the ribs has been noted (Wilbur et al. 2009: 1992). One of the key points that Wilbur et al. (2009) make in their paper is that a conservative method should be employed when seeking a differential diagnosis, and for caution to be taken before destructive analysis is carried out. They cite Hershkovitz et al. (2008) as an example of a case where destructive analysis was carried out due to lesions on the bones which they do not consider characteristic of tuberculosis. These lesions include osteomyelitis of the long bones, which Wilbur et al. (2009:1992) writes is more common with *Staphylococcus aureus* and *Streptococcus* infections.

Roberts (2015: S118) takes a different view of tuberculosis in human remains. Her review of published literature on the subject details what she refers to as pathognomonic indicators. Roberts, who has had a prolific career investigating tuberculosis in skeletal and mummified remains, writes that "the pathognomonic changes are to be found in destructive lesions, with little or no new bone formation; these changes are especially seen in the lower thoracic and lumbar spine. The hip and knee joints can also be affected, but any bone of the body may be involved" (Roberts 2015: S118). She writes that non-pathognomonic indicators "may include bone formation of the visceral surfaces of ribs, calcified pleura or granulomatous lung modules, destructive lesions of the bone underlying the skin lesions of lupus vulgaris, bone formation particularly on long bones, as seen in hypertrophic pulmonary osteoarthropathy, tuberculous dactylitis of the short bones of the hands and feet, and bone changes possibly as a result of tuberculous induced meningitis on the endocranium or gastrointestinal tuberculous involvement of the pelvic bones" (Roberts 2015:S118). The differences between pathognomonic and non-pathognomonic according to Roberts (2015) are determined by the locations of the lesions and whether any new bone growth has occurred. She stresses in the above quotes the complete destructive quality of tuberculosis and the central focus of the disease on the lower thoracic and lumbar vertebral bodies.

Within the last twenty years, the use of molecular biological techniques to aid archaeologists in the identification of disease has greatly increased. *Mycobacterium tuberculosis* was one of the first organisms to be subject to this type of analysis (Baron et al. 1996, Müller 2015). The insertion sequence 6110 (IS6110), a repetitive element marker in the tuberculosis genome, has been amplified from DNA extracted from bony tissue in skeletal remains (Roberts and Buikstra 2008). It has long been thought that the presence of IS6110 correlated with prior tuberculosis infection of the individual and would corresponds to the lesions found on skeletal remains which are characteristic of osteological tuberculosis. At the beginning of DNA research on tuberculosis and other diseases in 1994, it was widely thought that this could be the answer to finally being able to say with certainty whether or not a person had been infected with tuberculosis, and whether or not the osteological lesions that bioarchaeologists were seeing correlated with IS6110 and therefore tuberculosis DNA (Spigelman and Lemma 1993). Spigelman and Lemma (1993) were the first to isolate IS6110 from archaeological remains and since then, the numbers of bioarchaeologists who have done the same have multiplied rapidly, especially given the ease of use that modern molecular biology affords.

Although many researchers have reported successful results from their efforts to amplify IS6110 from skeletal remains, there has yet to be a comprehensive study of the specificity and sensitivity of this method (Baron et al. 1996, Roberts and Buikstra 2009, Green 2014). Due to the nature of archaeological research, many of the studies which have successfully amplified IS6110 from vertebrae and ribs have been based on very small sample sizes. Not surprisingly, given the often slow process by which tuberculosis causes spinal pathology, several studies have reported skeletal remains that showed no evidence of tuberculosis but did yield positive IS6110 results. This phenomenon could be caused either by the individual in question having a disease that was progressing towards spinal pathology but which was not fully developed before they died, or a problem with using IS6110 as the detection method. With Müller’s et al. 2015 publication reporting the identification of IS6110 from soil bacteria, the specificity of IS6110 has recently been called into question (Müller et al. 2015). Soil bacteria, from an archaeological research standpoint, are always going to be a possible source of contamination.

Meta-analysis of IS6110

A meta-analysis of primary research studies that amplified IS6110 from archaeological skeletal remains with lesions consistent with tuberculosis infection carried out for this thesis determined that there was very little correlation between osteological lesions and IS6110 DNA. A combined sample size of 18 studies, including Werner's 2015 data from the MCPFC, and 193 combined individuals was utilized, and a Bayesian prior proportion was calculated. The studies included in the meta-analysis all examined skeletal remains of an archaeological nature for lesions consistent with *Mycobacterium tuberculosis* infection. Only research articles that have used PCR to amplify IS6110 for the molecular detection of tuberculosis from DNA extracted from bone tissue were included. Studies were excluded if they used mummified remains instead of skeletal remains, if they did not state which samples were both IS6110 positive and lesion positive, and if they used juvenile remains exclusively. If a study included both adult and juvenile individuals, the adults were included and the juveniles were excluded. The British samples from Green (2014) were excluded due to his statement that they were the same individuals included in Bouwman et al. (2005). Individuals were not excluded due to unknown age or sex because the purpose of this meta-analysis was to examine the proportion of individuals with osteological lesions that produced positive IS6110 results, not to attempt to correlate the presence of such lesions with age or sex.

Studies were not excluded due to spatial or temporal parameters. The individuals included in the meta-analysis came from the Americas, Europe, the Middle East, Asia, Africa from contexts spanning the period from 12,000BP (Hershkovitz et al. 2008) to the 20th century (Harkins 2013). The bone from which the DNA was extracted was also not considered because the difference between the IS6110 results depending on the site of extraction was not a focus of the analysis. Table 1 presents a summary of the eighteen studies included in this analysis.

Table 4.1. The eighteen studies included in the meta-analysis with counts of IS6110 positives and information about the archaeological site contexts.

Year	Author	Positive IS6110	Negative IS6110	Total Samples	Sequenced	Continent	Bone	Century
1996	Baron	3	0	3	No	Europe	Various	19th
2002	Mays	1	6	7	No	Europe	Ribs	16th
2003	Mays	1	0	1	Yes	Europe	Vertebrae	8th
2003	Zink	6	10	16	No	Africa	Vertebrae	4,650 - 3,550 BP
2005	Bouwman	0	5	5	Yes	Europe	Vertebrae and Ribs	17th and 19th
2005	Donoghue	1	0	1	No	Middle East	Phalanx	1st
2005	Zink	3	14	17	No	Africa	Vertebrae	1,270 BP
2006	Raff	5	0	5	No	Americas	Ribs	13th
2008	Hershkovitz	2	0	2	No	Middle East	Various	12,000bp
2009	Murphy	2	3	5	Yes	Asia	NA	4th - 8th
2010	Klaus	1	1	2	No	Americas	Vertebrae	12th and 15th
2010	Müller	16	42	58	Yes	Europe	Vertebrae and Ribs	5th - 18th
2012	Nicklisch	3	13	16	No	Europe	Various	8,400 BP
2013	Harkins	7	17	24	Yes	Americas	NA	8th - 20th
2014	Green	4	4	8	Yes	Europe	Vertebrae and Ribs	11th - 18th
2015	Hajdu	1	0	1	Yes	Europe	Ribs	13th
2015	Posa	4	9	13	No	Europe	Various	17th
2015	Werner	5	4	9	No	Americas	Vertebrae	20th

Eighty-nine individuals of known age and sex from the MCPFC were analyzed for osteological markers of tuberculosis and are included in the meta-analysis results (Werner 2015). These eighty-nine were chosen because they had vertebrae present, they had been analyzed previously for age and sex, and they were conclusively adults. One individual was included who did not have a known age or sex, but presented such prominent osteological lesions on the thoracic vertebrae that it was decided to test for the presence of IS6110.

After examination, each individual was recorded as being either positive or negative for the presentation of osteological tuberculosis based on the presence of two or more indicators on either the thoracic or lumbar vertebrae. If present, the individual's ribs were also included in the analysis in order to look for osteolytic lipping or deterioration that could suggest the presence of tuberculosis. All of the individuals listed as being positive for osteological lesions had some presence of pathology on their associated ribs. For the individuals that were considered positive, bone tissue was taken from the site of the lesion on one of the vertebrae. Though the ribs were examined, they were not included in the sampling. The individuals who presented no osteological evidence of tuberculosis were a sampled as well, with bone tissue collected from a healthy-looking thoracic vertebra.

The DNA from all eighty-nine individuals was extracted from the vertebral bone tissue using organic methods (Pagan et al. 2012:119). This included an overnight incubation with proteinase-K at 37 degrees Celsius in order to digest the bony tissue prior to DNA extraction. Guidelines for working with aDNA were followed according to Bouwman et al. (2005) and Wilbur et al. (2009). Due to the nature of working with paleodisease as opposed to ancient human DNA, the consideration of contamination of samples by human workers was not seen as a significant risk. The MCPFC collection had been handled by many people between the year of excavation and the year of the current study, with no way of knowing if any of the excavators and curators were positive for tuberculosis. The primary author on this study was tested for tuberculosis and was found to be negative. Nonetheless, the samples were handled in a Biosafety Laboratory 2 (BSL2) facility, the Turner Lab, and all work was done according to Center for Disease control BSL2 standards based on the protocol approved by the Biosafety office of the University of Wisconsin-Milwaukee. All work was done using a negative airflow hood, the personnel of the laboratory was restricted to the primary researcher, and before handling all pipette tips and Eppendorf tubes were from sterile packaging. Eighty-eight of the samples resulted in successful DNA extractions with enough material present to be able to run PCR.

Along with negative controls and a positive control taken from the H37Rv strain of *M. tuberculosis*, the samples were amplified by Polymerase Chain Reaction (PCR) for IS6110. The primers for the reaction were specially designed using the parameters from Nerlich and Losch (2009), and Taylor et al. (1996). The forward primer was 5'-CCTGCGAGfCGTAGGCGTCGG-3'and the reverse was 5'CTCGTCCAGCGCCGCTTCGG-3'. The same primers were used in the dissertation research, as well as the other 16 studies included in the meta-analysis. The denaturation step was run at 94 degrees Celsius for one minute followed by 35 cycles of 94 degrees for 30 seconds, 68 degrees for 1 minute, and 72 degrees for 1 minute. The final annealing step was run for 3 minutes at 72 degrees Celsius. The amplified DNA was sent to the DNA Sequencing Facility at the University of Wisconsin Madison where the samples were run on Sodium Boric Acid (SBA) gels and were analyzed for the presence of a 123 base pair band that would show the presence of IS6110. No negative controls or blanks showed the 123 base pair band, whereas the positive control did show the expected band.

Eleven of the eighty-eight samples showed a band at the 123 base pair mark. Five of the nine samples that were categorized as positive for osteological tuberculosis markers, showed a presence of IS6110. Seven of the 17 studies included in this meta-analysis were sequenced.

Sequencing the extracted DNA and to obtain more of the tuberculosis genome is a more thorough and possibly more necessary route of determining whether there truly was *Mycobacterium tuberculosis* present in the sample. However, the question posed by this meta-analysis was not whether sequencing helps confirm the results of IS6110 analysis, but whether the presence of IS6110 itself shows a correlation with the presence of osteological lesions, particularly from the body of work that has already been produced in order to inform further research. For this reason, the results of the seven samples that were sequenced were chosen based on the presence of IS6110 as performed by electrophoresis analysis and not based on the sequencing results.

A Bayesian evidence synthesis was completed for the 17 studies included in the meta-analysis as well as the MCPFC data, for a total of 18 studies. The goal of a Bayesian synthesis in a meta-analysis is to update the proportion of success study by study, beginning with the earliest datum, in this case Baron et al. (1996). This produces a Bayes Factor that was synthesized from a total of 193 observations. While Spigelman and Lemma (1993) was the first study to include an analysis of IS6110 along with their bioarchaeological analysis, they did not include all of the data necessary in their study to be included in the meta-analysis. The Bayes Factor is the degree of support for Model 1 over Model 2. For this thesis the models are the probability that a bone with a tubercular lesion will also be positive for IS6110. Model 1 is a probability of 0.90, meaning that the marker is a very good indicator. Model 2 is a probability of 0.50, meaning that the marker is not a good indicator. The Bayes Factor then shows the evidential strength of one model over the other, with a value above 1.0 supporting the evidence that Model 1 is better supported than Model 2, and a value under 1.0 supporting Model 2 over Model 1. The evidential strength is: 0.07 to 0.10; strong, 0.05 to 0.69; very strong, less than 0.05; decisive.

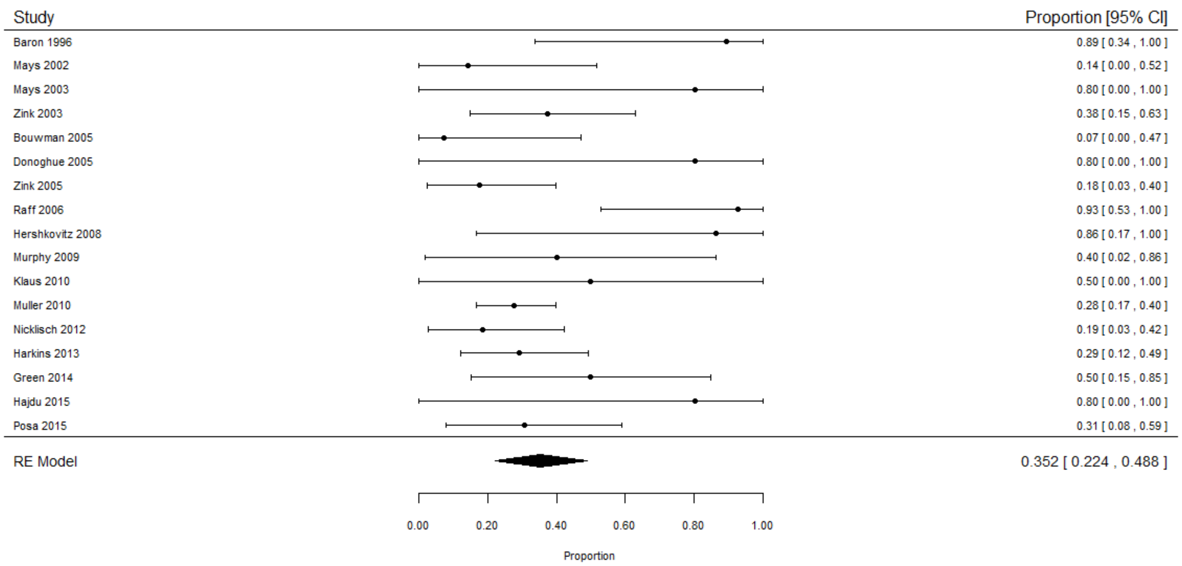


Figure 4.3. Forest plot showing the proportions and 95% Confidence Intervals for the seventeen studies that comprise the prior proportion of IS6110 positives included in the meta-analysis.

Figure 4.3 reveals the individual proportions of positive IS6110 results from skeletal elements with lesions and 95% Confidence Intervals of each of the 17 studies included in the meta-analysis. The individual proportions ranged from p=0.07 (Bouwman et al. 2005) to p=0.93 (Raff et al. 2006). The combined proportions gave a p=0.3518 (95% CI: 0.2240 - 0.4880) when the studies were subjected to a random effect meta-analysis model. The data were transformed using a Freeman-Tukey Distribution due to its ability to approximate a normal distribution. A random effect model was chosen in order to better approximate the current studies as having come from a larger population of research (Hedges and Veavea 1998).

Table 4.2. Model 1: The probability that a bone with a lesion will be positive for IS6110 is around 0.9 [marker is a good indicator]. Model 2; The probability that a bone with a lesion will have the marker is around 0.5 [marker is not a good indicator]. The Bayes factor is the degree of support for Model 1 over the depress of support for Model 2. If the value is greater than 1.0, model 1 is better than model 2. When the BF is below 1, Model 2 is better than Model 1. Evidential strength is: 0.07 to 0.10 strong, 0.05 to 0.69 “very strong” less than 0.05 “decisive” (Goodman 1999).

Date	Cumulative Trials	Cumulative Successes	Bayes Factor
1996	3	3	3.10
2002	10	4	0.24
2003	27	11	0.17
2005	50	15	0.06
2006	55	20	0.10
2008	57	22	0.12
2009	62	24	0.12
2010	122	41	0.07
2012	138	44	0.06
2013	162	51	0.06
2014	170	55	0.06
2015	184	60	0.06
2016	193	65	0.07

Table 4.2 shows the Bayes Factors and theta distributions for the 18 studies. Figure 4.4 shows the density plots of the posterior distributions, starting with Baron et al. (1996) and ending with the MCPFC data. Results showed that the prior proportion of IS6110 positives from a sample of individuals with osteological lesions is p=0.3518. The results of this study suggest that either IS6110 is a poor means of identifying Mycobacterium tuberculosis DNA or that osteological lesions are not a good predictor of IS6110 status. In terms of prediction, this study indicates that given the presence of osteological lesions, there is only a probability of 0.3518 of selecting one that is positive for the marker IS6110.

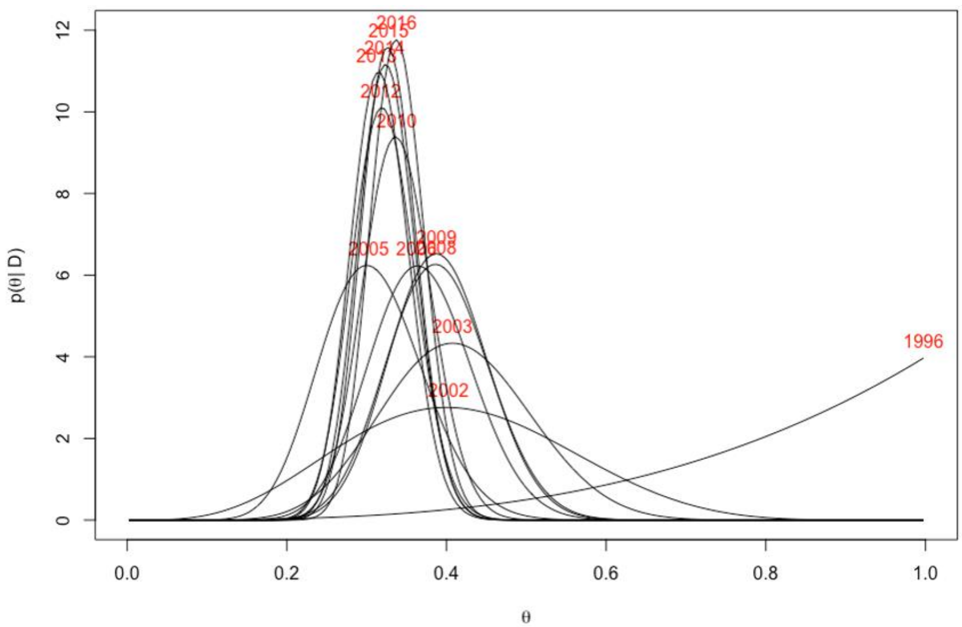


Figure 4.4. Theta and the probability of theta occurring, starting with the earliest data and combining cumulatively as time increases, ending with the MCPFC data in 2015.

Due to the small sample size in most bioarchaeological research, a meta-analysis was performed in order to address the proportion of IS6110 positives from skeletons exhibiting osteological lesions consistent with prior tuberculosis infection. Data from the Milwaukee County Poor Farm Cemetery were used in this analysis as an update to the prior proportion in conjunction with a Bayesian evidence synthesis. The Bayesian analysis concluded that osteological lesions are not a good predictor of the presence of IS6110 in recovered DNA (Figure 4.4). The reasons for why this may be should be explored by further research. The benefit of this analysis for bioarchaeological research is that it can help draw out conclusions from a population of studies that are often contradictory. This analysis served as a review of previous research on IS6110 and osteological tuberculosis, an update to the previous study using the Milwaukee County Poor Farm Cemetery collection, and a template for future studies that might apply a Bayesian evidence synthesis to examine relationships between studies reporting inconsistent results.

Brucellosis

Like tuberculosis, brucellosis is of zoonotic origin with bovine hosts in which infection can spread through milk. With the earliest known case of skeletal brucellosis being reported in *Australopithecus afarensis,* the origins of brucellosis, much like tuberculosis, are much older than humans (D'Anastasio et al. 2011: 150). Brucellosis is caused by three different organisms in the *Brucella* genus: *B. melitensis, B. abortus,* and *B. suis*. The second of these is named after the infection's propensity for causing spontaneous abortions.

The majority of human infection with brucellosis comes from interaction with bovids in farming communities. Due to the transfer of brucellosis placentally, often times humans initially become infected by helping bovids and camelids deliver their young (D'Anastasio et al. 2011). The symptoms in humans can present similarly to tuberculosis and other respiratory diseases, including pneumonias, but brucellosis is spread only rarely through aerosol inhalation, and is more commonly spread through skin to skin contact. Most importantly for this discussion, brucellosis often spreads to the bone marrow and causes osteoarticular lesions, usually in the lumbar and sacral spines. In radiological studies, this presents as an anterosuperior sclerosis of the spine (D'Anastasio et al. 2011: 149). In the vertebrae themselves, this more often looks like frequent sclerotic reactions on the posterior intervertebral areas (D'Anastasio et al. 2011: 150). Rib lesions are also considered secondary to vertebral lesions, much like tuberculosis. The osteological difference between tuberculosis and brucellosis is that brucellosis is usually clustered exclusively in the lumbar and sacral spines, and is less likely to occur in the thoracic vertebrae (D'Anastasio et al. 2011: 154).

Streptococcus pneumoniae

Pneumonia was one of the leading causes of death at the time that the Milwaukee County Poor Farm was in operation, and still is in most of the world today (Acuna-Soto et al. 2011: e234671). In the United States, it remains the leading cause of infectious death (Armstrong et al. 1999: 65). Pneumonia, however, is a very broad term for a symptom, rather than the name of a pathogen. Pneumonia, an infection of the lungs, is highly dangerous and can have both viral and bacterial causes. Tuberculosis and brucellosis both have pneumonia as symptoms. During the 1918 influenza epidemic, secondary infections caused by various bacterial pathogens were the cause of death for many (Rosner 2010: 43).

In this dissertation, *Streptococcus pneumoniae* was chosen because migration to the spine is known to occur (Murillo et al. 2014: O33). The *Streptococcus pneumoniae* pathogen, along with pneumonia, causes many common infections such as otitis media, meningitis, and septicemia following surgery (Leung et al. 2012: 2419). Like tuberculosis and brucellosis, it would be rare for the cocci to move from the lungs to the vertebral tissue, but clinical observations show that of the various *Streptococcus* species, it is statistically more often found in the vertebrae compared to other species (Murillo et al. 2014: O37). Murillo et al. (2014) found that the presence of endocarditis, infection in the endocardium of the heart, made the presence of *S. pneumoniae* more likely to cause vertebral infection. Murillo et al. (2014: O35), which was a clinical study, found that back pain was the most common symptom of infection and that the most common site of infection was the lumbar vertebrae.

Moving Forward

The people included in this analysis exhibiting spinal symptoms would have been in great amounts of pain and would have had possibly debilitating symptoms (Jeong et al. 2014: 22). Life with tuberculosis, brucellosis, or any form of pneumonia is not easy. The symptoms of these diseases and their mortality rates have been discussed. The spinal infection alone, however, would have caused its own symptoms. Long after the respiratory symptoms went away, fever, limb pain, neurologic deficit, sensory loss, and paralysis would all be possible (Jeong et al. 2014: 23). Regardless of the infectious cause of the lesions, the lesions themselves would have had an effect on person's health. Jeong et al. (2014: 23) and D'Anastasio et al. (2011) both found that diabetes, renal failure, and liver cirrhosis made a person predisposed for an infection to migrate to the skeletal system. This further illustrates the difficult lives of the people suffering from these diseases. The goals of this dissertation were to help the process of identifying individuals from the MCPFC and further knowledge of the bioarchaeology of disease, but more than that I want my work to bring humanity to the numbers.

With the aim of increasing personhood and reducing the distillation of people to data points, one of the goals of this dissertation was to use dental calculus to suggest a move away from destructive techniques that can still give us molecular biological data. Dental calculus is calcified dental plaque, and therefore contains a selection of what was in the individual's mouth at their time of death. Dental calculus has been used since 2011 to study indicators of health in skeletal populations ranging from diet to disease (Preus et al. 2011: 1828). Notably, both bacteria and viruses may be isolated from dental calculus as well as ancient plant material, showing that the robusticity of dental calculus as an archaeological material is likely to make this a new and exciting source of data for archaeologists.

Young and Warner-Smith (2017) recently was able to amplify *Mycobacterium tuberculosis* from dental calculus. Respiratory infections, including the three that this dissertation will study, tuberculosis, brucellosis, and bacterial pneumonia, often cause coughing, which will bring sputum up from the lungs and into the back of the throat therefore coming into contact with the molars. The work of Young and Warner-Smith (2017) and Huynh et al. (2016) provide evidence that this sputum comes in contact with the dental plaque of the individual and is retained after death and burial. Their work supports the recent push from bioarchaeologists to explore dental calculus as a source of bacterial DNA, and supports this dissertation's examination of dental calculus as an alternative source for information about the diseases an individual suffered from without the disease needing to have caused osteological lesions nor for the destruction of bone to occur.

Chapter 5

Methods

MCPFC Sample

My goal for the selection of the sample analyzed in this thesis was to examine the remains of 100 individuals from the Milwaukee County Poor Farm Cemetery from the 1991/1992 excavation. The University of Wisconsin-Milwaukee Archaeological Research Laboratory maintains final disposition of the remains from the 1991/1992 excavations. The final disposition of the remains from the 2013/2014 excavations has yet to be decided, which is why destructive analysis on the remains from the 2013/2014 excavations was not possible. The individuals who were chosen needed to have vertebrae present, be conclusively adults, and if possible have been assigned a sex estimate. This resulted in a sample of 89 individuals.

Following Buikstra and Cook (1980: 443), I excluded sub-adults from my sample. In their seminal work, they describe how the presence of metabolic diseases in sub-adults can oftentimes be confused with tuberculosis lesions. Lesions from tuberculosis would not have had time to develop in sub-adults and so the presence of lytic lesions caused by other diseases would only negatively affect the data. For juveniles that do have lesions caused by an infectious disease, the patterning can be different than what is expressed in adults. Due to the difference in vascular supply in juveniles, lesions from infectious diseases can have a different pattern of presentation as well as a different primary focus (Buikstra and Cook 1980: 442).

Adults with a previously determined sex estimation were included in the sample. The 1991/1992 excavated individuals from Cemetery II had previously been analyzed for sex and age. Individuals who were marked as having an "Unknown" or "Ambiguous" sex were excluded.

An exception was made for the individual who was buried in Burial 7230. Burial 7230 was included in Milligan's 2010 dissertation and the individual showed signs of tuberculosis lesions. This individual had both an "Unknown" sex and age.

Overwhelmingly, the individuals included in this dissertation sample were middle adult males. The age categories are as follows: Young Adult (18-34.5 years), Middle Adult (35-49.9 years), and Old Adult (50 years and older) (Richards et al. 2016: 27). These categories were assigned during the analysis of the 1991/1992 materials. In this dissertation sample, 16.27% of the sample was female, 82.56% was male, and 1.16% accounted for the single sample that had an unknown sex. Middle adults were the most prevalent for both sexes. 61.63% of the sample was middle adult, 19.77% was young adult, and 17.44% was old adult. Once again, 1.16% of the sample had an unknown age, accounting for the same sample with an unknown sex. These percentages are similar to the overall population of the MCPFC Cemetery II burials (Richards 1997: 96). Middle adult males were the largest category, representing 55.81% of the overall sample.

Bioarchaeological Analysis

The age and the sex information for the remains were extracted from Milligan's 2010 dissertation work. Milligan worked from Buikstra and Ubelaker's "Standards for data Collection from Human Skeletal Remains" (1994) when performing the age and sex estimation (Milligan 2010). The bioarcaheological analysis drew heavily on the works of Buikstra and Cook (1980), Zink et al. (2003, 2005), and Hadju et al. (2012: 3-4). My sample excluded any individual who did not have vertebrae present. Individuals who had vertebrae present, I visually inspected the entire skeleton for signs of osteological tuberculosis. When looking for the lytic lesions that can be present with tuberculosis, the search focused on the thoracic and lumbar vertebrae (Buikstra and Cook 1980). A lytic lesion is one in which the bone would have been worn away, and lysis of the bone cells would have taken place (Taylor et al. 2005: 2236). These are particularly suggestive of tuberculosis. Bone deposition does sometimes occur, but is far less common in cases of tuberculosis than lysis (Holloway et al. 2013: 3). None of the individuals in my sample showed indications of having advanced Pott's disease, where the kyphosis of the spine is greater than 60 degrees (Taylor et al. 2005: 2236).

If a person exhibited lytic or reactive lesions on their thoracic, lumbar, or sacral vertebrae, I categorized them as being positive for lesions if the following criteria were also met: the lytic destruction was on the anterior body of the vertebra, the destruction was limited to the vertebrae body and was clearly not a manifestation of degenerative joint disease, the lysis was present in an asymmetrical pattern and was not consistent throughout the vertebral column, and the surface of the body of the vertebrae was destroyed or pitted in such a manner in which it was clear that periosteal reactions and/or remodeling had also occurred and there was no possibility of post-mortem damage (Buikstra and Cook 1980). The anterior body of the vertebrae was examined closely as this is a far more common place for tuberculosis lesions to manifest themselves than the posterior aspect (Holloway et al. 2013: 1). I examined the ribs in detail as well, particularly if it was a thoracic vertebrae that showed evidence of lytic lesions. The evidence for being able to identify tuberculosis based solely on rib lesions is not strong, but the overall pathology on the ribs was taken in to account when I made my designation (Nerlich and Losch 2009).

DNA Analysis

The DNA collected from the vertebral tissue in 2015 was used again for this dissertation research. Dental calculus samples were taken from the individuals in the Milwaukee County Poor Farm Cemetery collection whose vertebral bone tissue had previously been collected by Werner (2015). All individuals had dental calculus removed from the mandibular molars if possible. Molars were used due to their close proximity to the vocal tract and site of sputum congestion. Collection protocol for the dental calculus samples followed the suggestions of Pagan et al. (2012:120). The samples were handled with extreme care following the recommendations of Wilbur et al. (2009) for working with ancient DNA. A sterile scalpel blade was used to scrape the collection site. Two hundred to four hundred milligrams of dental calculus were collected (Benoit et al. 2013). After being scraped off the tooth by a sterile blade onto a clean sheet of collection paper, the dental calculus was poured from the paper directly into a sterile 1.5mL Eppendorf tube. Müller et al. (2015) found evidence of IS6110 in soil bacteria, which is why three matrix samples from different parts of the cemetery were also run in order to provide an overview of possible soil contamination by the bacteria of interest. The initial bioarchaeological analysis in 2015 started with 89 individuals. 85 of those were able to have DNA collected. Out of the same sample, 47 individuals had dental calculus that could be collected and which DNA was successfully extracted from. Three soil samples taken from the matrix from Burials 5168, 7172, and 8174 were also analyzed and DNA was successfully extracted from them.

An organic DNA extraction was carried out on the dental calculus according to the parameters outlined in Pagan et al. (2012:119) and following the same methods as Werner (2015). 10 microliters of Proteinase-K were added to each sample along with 700 microliters of

TENS (10mM Tric-HCl, 0.1 mM EDTA, 100mM NaCl, 2% SDS, pH 8) buffer. After a vigorous vortexing, the samples were incubated at 56 degrees Celsius overnight. In the morning, the samples were centrifuged for three minutes at 1500 rpm and the supernatant was removed. 500 microliters of 25:24:1 phenol/chloroform/isoamyl alcohol was added to each sample and they were vortexed until a milky precipitate formed. The samples were then centrifuged for 20 minutes at room temperature at 12000 rpm and the upper aqueous phase, about 400 microliters, was transferred into a new sterile tube. Another 500 microliters of the of 25:24:1 phenol/chloroform/isoamyl alcohol was added to each sample and they were once again vortexed until milky and then centrifuged at 12000 rpm for 20 minutes at room temperature. The upper aqueous phase, about 120 microliters, was transferred into a new sterile tube and 40 microliters of sodium acetate (3M, pH 5.2) were added. Along with the sodium acetate, 1100 microliters of -20-degree Celsius 100 percent ethanol were added. The tubes were mixed by inversion and then chilled in a -80-degree Celsius freezer for 40 minutes. After chilling, the samples were centrifuged at 13000 rpm for 30 minutes at room temperature. The supernatant was removed and the pellets were allowed to air dry under a biological hood. Once free from ethanol, the samples were eluted in 50 microliters of TE buffer.

Baron et al. (1996) was one of the first studies that used IS6110 that was extracted from human remains to look for the presence of tuberculosis and go into great detail about their methods. IS6110 had been already known to be part of the tuberculosis genome and had been used to identify the disease in living individuals, but Baron et al. (1996) was one of the first to apply this to archaeological material, following the work of Spigelman and Lemma in 1993. Nerlich et al., in 1997, applied similar techniques as Baron et al. (1996) to Egyptian mummies. Mummies with organ present will always yield greater amounts of DNA than skeletal tissue alone, and Nerlich et al. saw success in their methods (Nerlich et al. 1997). It was around this time that Faerman et al. (1997) found IS6110 in skeletal remains without visible osteological lesions. Haas et al. (2000:294) provides a history of the use of molecular biology to detect IS6110 in skeletal remains up until the year 2000. Nerlich and Losch (2009) used the same methods as Nerlich et al. in 1997 with similar results. It was not until Müller et al. (2015) where the usefulness of using IS6110 to infer the presence of tuberculosis came into question. The DNA analyzed in this dissertation had been extracted and had PCR run for IS6110 immediately prior to the publication of Müller et al. (2015). Following the work of Müller et al. and the results from the 2015 thesis, which are presented in Chapter 4, I formed my own doubts about the utility of using IS6110. For this dissertation, I used the same methods as these previous studies, the same methods that I had in my master's thesis, in order to compare apples to apples and to test not only my own previous results but the methods as a whole.

Both Pagan et al. (2012:120) and Benoit et al. (2013) examined the yield from organic extractions versus utilizing a silica gel matrix and found that the yield is not improved enough using a silica extraction method to justify the increased cost. Benoit et al. (2013) found that the best yield was obtained when the sample was first pulverized in order to increase the amount of surface area exposed to the demineralization chemicals. Weyrich et al. (2015:121) found that dental calculus samples can be treated in the same manner as skeletal remains for DNA extraction with the addition of a 48-hour incubation with EDTA and Proteinase K to facilitate demineralization (Pagan et al. 2012:120, Benoit et al. 2013, Zink et al. 2003, Adler et al. 2013). The dental calculus samples from the MCPFC were pre-treated as such.

The dental calculus samples were amplified by Polymerase Chain Reaction (PCR) for IS6110 using the same methods and primers as used by Werner (2015). The primers for the reaction were specially designed using the parameters outlined in Nerlich and Losch (2009) and Taylor et al. (1996). The forward primer is 5'-CCT GCG AGC GTA GGC GTC GG-3'and the reverse is 5'-CTC GTC CAG CGC CGC TTC GG-3'. The products were run by gel electrophoresis and analyzed for the presence of a 123 base pair band that would show the presence of IS6110. The DNA already collected from Werner (2015) and the DNA extracted from the dental calculus were amplified for *Streptococcus pneumoniae* and Brucellosis. The PCR methods from Leung et al. (2012:2420) for amplifying *Streptococcus pneumoniae* was followed in which the primers are as follows: cps1, 5'-GCA ATG CCA GAC AGT AAC CTC TAT-3' and cps2, 5'-CCT GCC TGC AAG TCT TGA TT -3'. This should produce a 1,061 base pair amplicon (Leung et al. 2012:2420). Brucellosis was amplified for based on the parameters discussed in Mutolo (2006). IS6501, an insertion sequence in *Brucella* species were amplified by the forward primer 5'- CGC GCG GTG GAT TGA C – 3' and the reverse primer 5' – AGC GGT AGG CCG ATA GCA – 3' and should produce a 58 base pair product (Mutolo 2006). The PCR conditions for each primer are in Table 5.1.

Table 5.1. The PCR conditions for the three primers used: IS6110, IS6501, and cps1.

	IS6110		IS6501		cps1	
1 cycle	94	1 minute	95	2 minutes	95	2 minutes
35 cycles	94	30 seconds	95	30 seconds	95	30 seconds
	68	1 minute	52	1 minute	52	1 minute
	72	1 minute	72	1 minute	72	1 minute
1 cycle	72	3 minutes	72	5 minutes	72	5 minutes

After the reactions were run, the samples were run on Sodium Boric Acid gels, and were analyzed for the presence or absence of a band. Positive controls of bacterial DNA, obtained from the Pepperell Lab at the University of Wisconsin Madison, were included and run before the samples to check that the PCR conditions were appropriate.

Statistical analysis of material culture

The material culture results from Richards (1997) were examined to see if there is a relationship between positive biomolecular or bioarchaeological results and certain types of material culture. The Category of goods for each burial was noted, along with what was specifically present in each. The burials have previously been classified using the material culture categories proposed by Richards (1997) in her discussion of the MCPFC. Richards classified Category I grave goods as being those which would have belonged to a resident of one of the county institutions and would contain only safety pins from burial shrouds or medical equipment. Category II grave goods are those which suggest that the person was sent to MCPFC from the County Coroner's office or were unclaimed by relatives in some manner and include small amounts of personal belongings. Category III goods are religious objects and represent the least common category of burials.

The results from this material culture analysis were looked at in conjunction with the DNA data in order to see if there is a statistical relationship between different types of material culture and the presence of pathogenic disease DNA. Due to the small numbers in the sample and the non-parametric data, Fisher's Exact Tests were used.

Chapter 6

Results

Bioarchaeological

The final results from the bioarchaeological analysis are presented in Table 6.1 All results, both bioarchaeological, molecular biological, and the results of Richards' 1997 material culture analysis can be found in Appendix A and Appendix B. Statistically, there was no correlation between presence or absence of lesions and either age or sex.

Table 6.1. Distribution of osteological lesions by age and sex.

	No Lesions	Lesions
Females		
Young Adult	5	0
Middle Adult	4	1
Old Adult	4	0
Males		
Young Adult	10	2
Middle Adult	44	4
Old Adult	10	1
	77	8
		Total 85

DNA Analysis

The results of the Sodium Boric Acid gels are summarized in Table 6.2. Statistical analyses in the form of a Fisher's Exact Test performed using the program R, found that there was a statistically significant association between the presence of osteological lesions and the presence of IS6110 in bone (OR = 9.52, p-value = 0.0085). However, only 36% of the cases that have positive IS6110 results also have lesions. The conclusion to be drawn from this is simply that it is unlikely for a person to have osteological lesions and also have positive IS6110 results. These results are exhibited in Figure 6.1. There were no other significant results when the bioarchaeological and DNA analyses were combined. There was no association between having pathogenic DNA in the dental calculus and having it also present in the bone. There were no associations between any of the DNA results and the age or the sex of the individual.

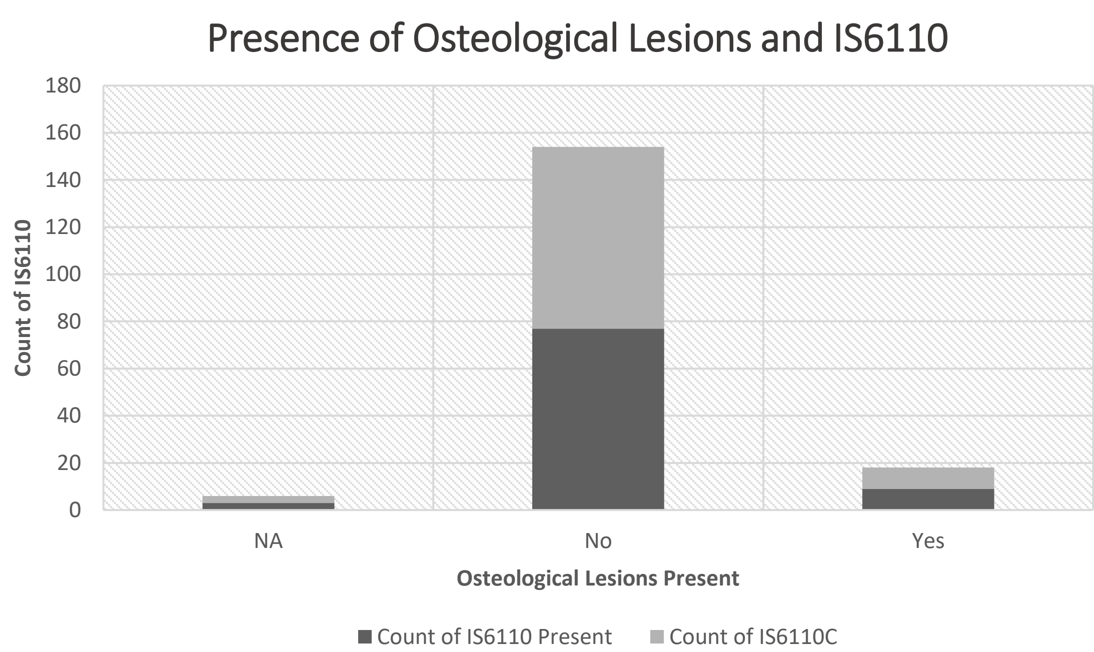


Figure 6.1. Comparison of prevalence of individuals with IS6110 in bone and osteological lesions.

There were two individuals, 1035 and 2007, whose results from the bone analysis and the dental calculus analysis were both positive. Neither of these individuals had osteological lesions. The person whose burial number is 1035 had IS6110 present in both their bone and their dental calculus. Bioarchaeological analysis shows this person to have been a young adult male who had Category I grave goods, indicating that they were most likely living in one of the county institutions before death. Burial 2007 was also found to be a young adult male and had no grave goods present in his grave. In the case of Burial 2007, IS6501 was found in both their bone and their dental calculus, indicating possible prior brucellosis infection. The complete list of results can be found in Appendix C.

One of the most notable results from this dissertation is that no presence of *Streptococcus pneumoniae* was found in either the bone or the dental calculus. The positive control showed a band at the 1,061 base pair mark on the gel but no other samples showed that band. The samples were re-run to make sure that this was in fact the case and the results from the second run were the same as the first. The discussion will address in more detail why this might be, when pneumonia was one of the most common causes of death at the time.

The other result that will be discussed at length in Chapter 7 is the positive IS6110 result that came from one of the soil samples. A sample of soil matrix taken from Burial 5168, which was not included in this analysis due to the lack of vertebrae, showed the presence of IS6110. In 2015, Muller found that IS6110 can be found in certain soil bacteria, and these results confirm that. This begs the question of how to proceed with DNA analysis from archaeological samples in the future when the pathogen is also found in the environment. Sequencing, due to its increased availability and decreasing cost, may be necessary as opposed to methods which rely on amplification of a marker sequence.

Statistical analysis of material culture

A Fisher's Exact Test found that there was a statistically significant correlation between people who had osteological lesions and those with material culture in their graves that could be categorized as Category I (Richards 1997: 209) (p-value = 0.0273). People buried with Category I material culture also were significantly more likely to have positive IS6110 results from their dental calculus (p-value = 0.0255). When Category I was broken down further into specific items and ran as a Fisher's Exact Test with the type of DNA found from the burial, I found that individuals who had evidence of tuberculosis in their calculus were found to be buried with glass (p-value = 0.0043) and safety pins (p-value = 0.0396) present in all cases. In some cases, people who did not show any disease were buried with of glass or safety pins, but not at a statistically significant level, while people with brucellosis DNA did not have any glass or safety pins in their burials.

Burial 9333 was the only burial included in the sample that contained Category III grave goods. The individual in the burial was a young adult female. Figure 5.1 shows the religious item, a rosary, that was included in Burial 9333 (Richards 1997: 262). The individual in Burial 9333 did not exhibit any signs of tuberculosis, either osteologically or in the DNA analysis. However, this individual stands out as being both a young female, which in itself is rare for an individual buried in the MCPFC, and for as having a religious item in her burial.

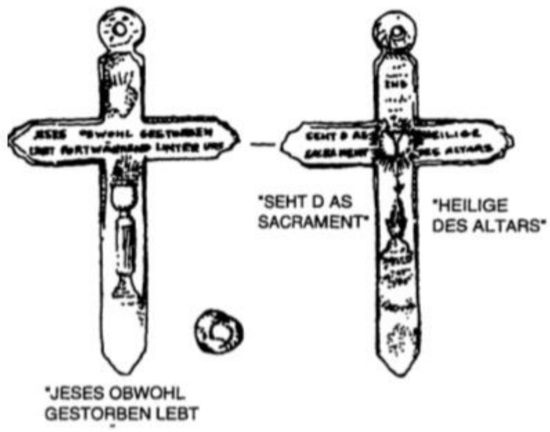


Figure 6.2. A rosary obtained from Burial 9333 (Richards 1997:262)

The presence of religious items suggests a certain amount of care was taken with regards to the individual's burial, something which was uncommon with this population (Richards 1997: 251). The distribution of material culture present in this sample is presented in Figure 5.2.

Chapter 7

The Lives of the Poor

Relatively few identifications have been made for the people of the MCPFC to date. My colleagues have provided a small number of identifications, but the overwhelming majority of the people remain anonymous. The few people with potential known identities who were part of my dissertation work were researched through both the Milwaukee County Historical Society archives and the online archives of the Milwaukee Journal Sentinel. To my dismay, there were no obituaries, no newspaper articles discussing who was sent to Muirdale, and no discussion of the ongoing project that was the Milwaukee County Poor Farm between 1882 and 1925. What I did find were advertisements. Overwhelmingly in the Milwaukee Journal Sentinel between the years 1873 and 1915, besides the mentions of the building of Muirdale and the 1914 Milk Wars, the main way that consumption or tuberculosis is referenced is in advertisements for tonics to cure people of such ills. Figure 7.1 shows an 1887 advertisement from the Milwaukee Sentinel for a product that is guaranteed to cure consumption.

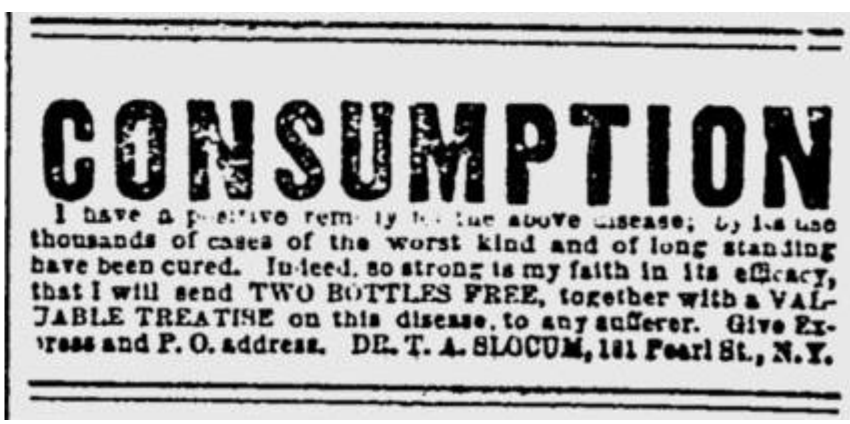


Figure 7.1. Advertising for two bottles free of a consumption tonic (1887 Milwaukee Sentinel edition).

While initially surprising, I began to see that absence of obituaries and surplus of advertisement for tonics was in reality quite telling about the daily lives of people living with tuberculosis at the time. The obituaries and stories that were found in the paper were of prominent people. The poor were not given any mention. Indeed, the poor who died of tuberculosis would not have garnered much attention at the time at all due to how common their condition was (Leavitt 1982: 26). A report of every poor person who died of tuberculosis would have filled the newspapers. Instead, newspaper advertisements aimed at the desperate and ill attempted to sell cures that were not ever going to work.

The end result of my goal of finding more information about the individuals included in my sample was disheartening. This lack of information proved to me that the othering process had begun well before MCPF first founded Cemetery II. The stigma and the othering process had long since pushed them and their stories to the margins. What we do have from this time period is the MCPFC Register of Burials, which lists what little information was known about those interred in MCPFC when they died. In a few cases I was able to use the data from my dissertation to augment some details about these already potentially identified people.

Adolf Wildiner, Burial 3039

Adolf Wildiner was 59 when he died on November 14th, 1923. Born in Austria, he was a laborer who was admitted to the County Hospital for tuberculosis of the illium and bronchial pneumonia. Found in Mr. Wildiner's grave upon excavation in 1991 and 1992 was a single safety pin. A Category I grave good (Richards 1997: 209) which meant that Mr. Wildiner was likely cared for at one of the county institutions and given a simple burial with just a shroud. Osteological lesions were found on Mr. Wilidiner's vertebrae and IS6110 was isolated from his bone tissue but not his dental calculus. This correlates well with the fact that he was admitted to the hospital for tuberculosis of the illium, meaning that the disease would have long since traveled out of his lungs (making it less likely to be in his sputum) and into his bone. He was married at the time of his death to Caroline Kielman, though no mention of her in the county records can be found, nor of a Caroline Wildiner.

TRANSCRIBED MILWAUKEE COUNTY DEATH CERTIFICATE

Certificate Vol./Page# 490/324

Vital Statistics					
Name of Deceased	Wildiner, Adolf			Sex	M
Date of Birth		Place of Birth	Austria		
Mother or Wife	Caroline Kielman				
Father or Husband	Emanuel Wildiner				
Occupation	Laborer				
Mortality					
Date of Death	14-Nov-1923	Age at Death	59		
Cause of Death	tuberculosis of illium, bronchial penumonia				
Place of Death	County Hospital				
Date of Burial	21-Nov-1923	Grave#	54-23	Excavated Lot#	3039

Figure 7.2. Death information for Adolf Wildiner (Richards 1997:560)

Helena Wickman, Burial 5238

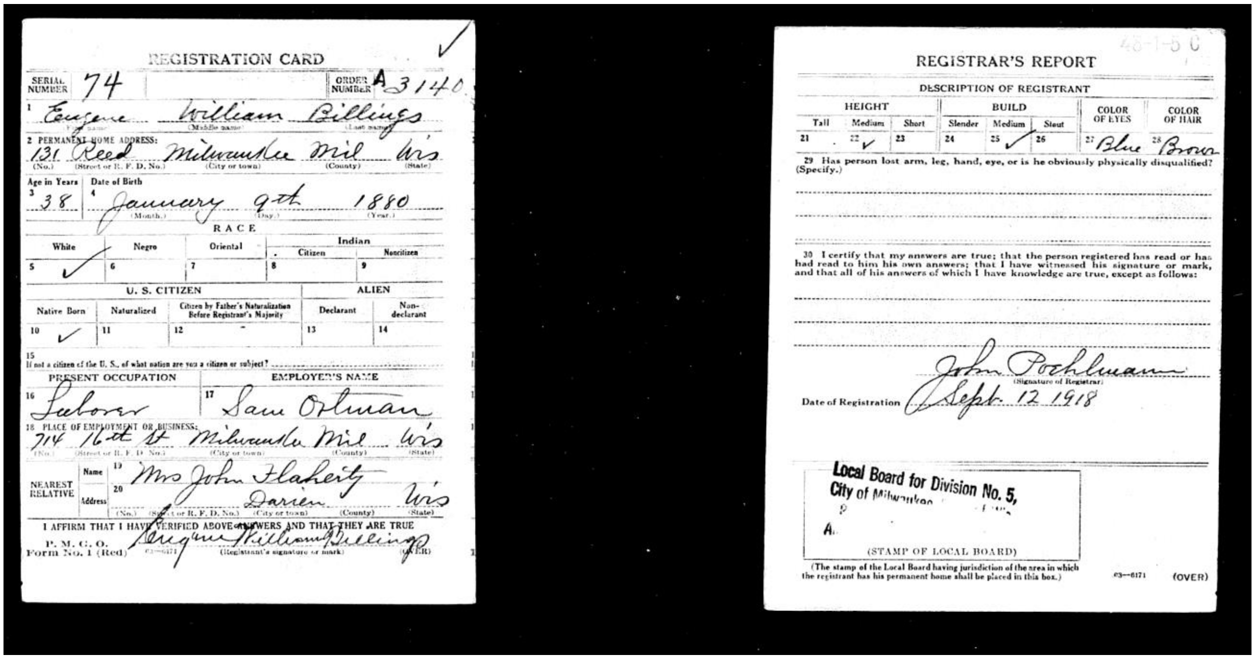
Helena Wickman was born in Germany and had no known occupation. On her death certificate, under “Father or Husband” the name Kare Frederick is listed, which was most likely a misspelling of Karl, without reference to whether that is her father or her husband. She was 76 years old when she died in the infirmary on March 19th, 1924. Ms. Wickman was brought into the hospital and died of “Carcinoma of Stomach”. Her burial was simple with only safety pins being found in her grave. Brucellosis DNA was found in her vertebral tissue. Brucellosis can cause gastrointestinal issues, and these data suggest that her stomach issues could have been related to brucellosis.

TRANSCRIBED MILWAUKEE COUNTY DEATH CERTIFICATE					
Certificate Vol./Page# 495/164					
Vital Statistics					
Name of Deceased	Wickman, Helena			Sex	
Date of Birth	25-Jan-1848	Place of Birth	Germany		
Mother or Wife					
Father or Husband	Kare Friedrick				
Occupation	none				
Mortality					
Date of Death	16-Mar-1924	Age at Death	76		
Cause of Death	carcinoma of stomach				
Place of Death	Infirmary				
Date of Burial	19-Mar-1924	Grave#	5-24	Excavated Lot#	5238

Figure 7.3. Death information for Helena Wickman (Richards 1997:604)

Eugene Billings/ Larry Parks

Burial number 5207 is listed as being potentially either Eugene Billings or Larry Parks. According to his death certificate, Mr. Billings was born in Wisconsin and died at the age of 43 from pulmonary tuberculosis. He was a laborer on the Milwaukee Railroad and died in the county hospital on October 7th, 1923. I was able to obtain the draft registration card for Eugene Billings (Figure 7.4), as well as both the 1910 and the 1920 Milwaukee Census documents with his name on it.



REGISTRATION CARD

SERIAL NUMBER 74 ORDER NUMBER A 3140

1 Eugene William Billings

(First name) (Middle name) (Last name)

2 PERMANENT HOME ADDRESS:

131 Reed Milwaukee Mil Wis

(No.) (Street or R. F. D. No.) (City or town) (County) (State)

Age in Years 3 38 Date of Birth 4 January 9th 1880

(Month.) (Day.) (Year.)

RACE

White	Negro	Oriental	Indian: Citizen	Indian: Noncitizen
5 ✓	6	7	8	9

U. S. CITIZEN: Native Born	U. S. CITIZEN: Naturalized	U. S. CITIZEN: Citizen by Father's Naturalization Before Registrant's Majority	ALIEN: Declarant	ALIEN: Non-declarant
10 ✓	11	12	13	14

15 If not a citizen of the U. S., of what nation are you a citizen or subject?

PRESENT OCCUPATION 16 Laborer

EMPLOYER'S NAME 17 Sam Ortman

18 PLACE OF EMPLOYMENT OR BUSINESS:

714 16th St Milwaukee Mil Wis

(No.) (Street or R. F. D. No.) (City or town) (County) (State)

NEAREST RELATIVE Name 19 Mrs John Flaherty

Address 20 Darien Wis

(No.) (Street or R. F. D. No.) (City or town) (County) (State)

I AFFIRM THAT I HAVE VERIFIED ABOVE ANSWERS AND THAT THEY ARE TRUE

P. M. G. O. Form No. 1 (Red) Eugene William Billings (Registrant's signature or mark)

REGISTRAR'S REPORT

DESCRIPTION OF REGISTRANT

HEIGHT: Tall	HEIGHT: Medium	HEIGHT: Short	BUILD: Slender	BUILD: Medium	BUILD: Stout	COLOR OF EYES	COLOR OF HAIR
21	22 ✓	23	24	25 ✓	26	27 Blue	28 Brown

29 Has person lost arm, leg, hand, eye, or is he obviously physically disqualified? (Specify.)

30 I certify that my answers are true; that the person registered has read or has had read to him his own answers; that I have witnessed his signature or mark, and that all of his answers of which I have knowledge are true, except as follows:

John Poehlmann (Signature of Registrar)

Date of Registration Sept. 12 1918

Local Board for Division No. 5, City of Milwaukee

(STAMP OF LOCAL BOARD)

(The stamp of the Local Board having jurisdiction of the area in which the registrant has his permanent home shall be placed in this box.)

(OVER)

Figure 7.4 WWI Draft Registration documents for Eugene Billings

The information listed on his death certificate for his parents matches the information for the Eugene William Billings that I found online. In 1910, while he was 30 years old, he was living with his mother who was at that time a widow. Johanna Billings was born in Ireland and was listed as the head of the household on the 1910 census (1910 Wisconsin Census). In the 1917 draft documents, his home address was listed as 131 Reed St in Milwaukee, Wisconsin. The documents describe him as being white, native born, of medium build and height, and having brown hair and blue eyes. He would have been 38 years old at the time. I could find no information stating that he had ended up going to war. In the 1920 census, three years before he died, Mr. Billings was listed as being a roomer at a boarding house and a laborer on the railroad (1920 Wisconsin Census).

Mr. Parks was born in Pennsylvania and died at age 70 of carcinoma of the liver on October 6th, 1923. His occupation was the laborer of a Great Lakes steamship. Both of the men were buried on October 12th, 1923. Based upon the data that were collected for this dissertation, I would like to make the case that Burial 5207 contained the body of Eugene Billings, and not Larry Parks. The age of the individual was calculated to be middle adult. The difference in the skeleton between a person of 43 years of age and a person of 70 years of age is usually great (Buikstra and Cook 1980). The person in Burial 5207 was buried with nothing but safety pins and had osteological lesions present on his vertebrae. No pathogenic DNA was isolated from either the vertebrae or the dental calculus, but I would suggest that based on the presence of lesions and the age at death, this burial most likely contained the remains of Mr. Eugene Billings.

TRANSCRIBED MILWAUKEE COUNTY DEATH CERTIFICATE

Certificate Vol./Page# 488/351

Vital Statistics					
Name of Deceased	Billings, Eugene			Sex	M
Date of Birth	9-Jan-1880	Place of Birth	Wisconsin		
Mother or Wife	Johanna Flaherty				
Father or Husband	John				
Occupation	Laborer, Milw. RR				
Mortality					
Date of Death	7-Oct-1923	Age at Death	43		
Cause of Death	Pulmonary tuberculosis				
Place of Death	County Hospital				
Date of Burial	12-Oct-1923	Grave#	45-23	Excavated Lot#	5214/ 5207

Figure 7.5. Death information for Eugene Billings (Richards 1997:598)

TRANSCRIBED MILWAUKEE COUNTY DEATH CERTIFICATE

Certificate Vol./Page# 489/157

Vital Statistics

Name of Deceased	Parks, Larry			Sex	M
Date of Birth	30-Sep-1852	Place of Birth	Pennsylvania		
Mother or Wife	Jane Hodge				
Father or Husband	Patrick				
Occupation	Laborer, Great Lakes Steamship				

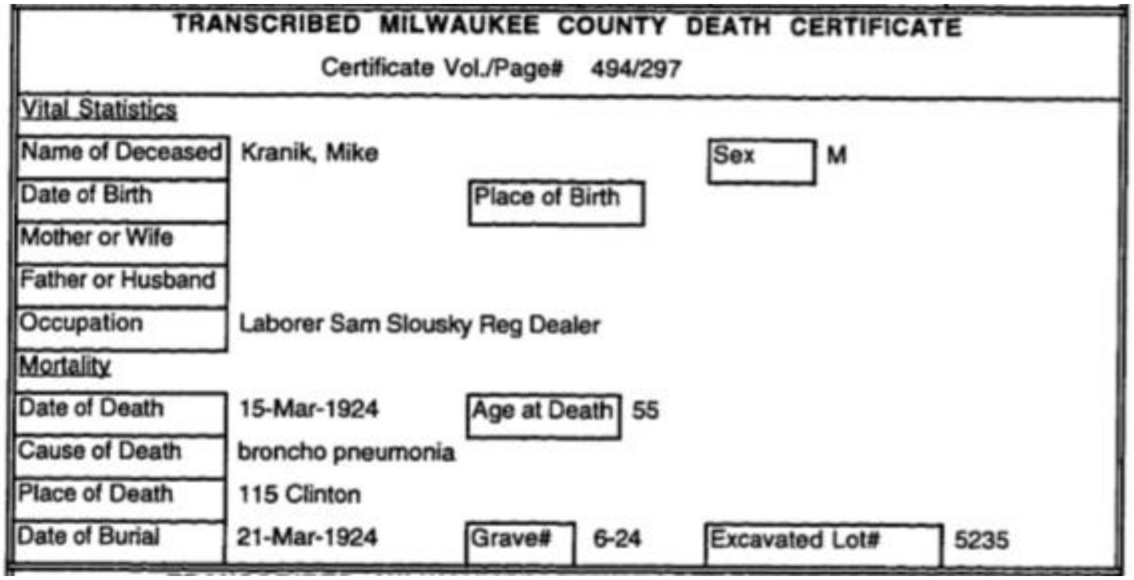
Mortality

Date of Death	6-Oct-1923	Age at Death	70		
Cause of Death	carcinoma liver (primary)				
Place of Death	County Hospital				
Date of Burial	12-Oct-1923	Grave#	46-23	Excavated Lot#	5214/ 5207

Figure 7.6. Death information for Larry Parks (Richards 1997:597)

Mike Kranik, Burial 5235

Mike Kranik died on March 15th, 1924 of broncho pneumonia. He was 55 when he died and had been working as a laborer. His place of death is listed as 115 Clinton. From Mr. Kranik's dental calculus, brucellosis DNA was extracted. It is possible that this was the cause of his pneumonia.



TRANSCRIBED MILWAUKEE COUNTY DEATH CERTIFICATE

Certificate Vol./Page# 494/297

Vital Statistics

Name of Deceased	Kranik, Mike			Sex	M
Date of Birth		Place of Birth			
Mother or Wife					
Father or Husband					
Occupation	Laborer Sam Slousky Reg Dealer				

Mortality

Date of Death	15-Mar-1924	Age at Death	55		
Cause of Death	broncho pneumonia				
Place of Death	115 Clinton				
Date of Burial	21-Mar-1924	Grave#	6-24	Excavated Lot#	5235

Figure 7.7. Death information for Mike Kranik (Richards 1997:603)

These stories are not as detailed as I would like them to be and not nearly as complete and complex as these people's lives actually were. They lend credence, I believe, both to these individual's having an agency all their own and to the erasure and stigma of their suffering.

The burying of the diseased

Schug (2016:3) found in her study of leper colony burials that the diseased were buried alongside the healthy. What the data collected from this dissertation show is that there was a correlation between people with osteological lesions and the presence of Category I artifacts (Richards 1997: 209). There is also a significant correlation between people with IS6110 in their dental calculus and being placed in Category I. However, there was no correlation between people with IS6110 in their calculus and those with IS6110 in their vertebrae, nor was there a significant correlation between IS6110 in dental calculus and the presence of osteological lesions.

People who lived in the county institutions or died at the County Hospital and had no living or present relatives to be involved with the burial, were typically buried with a simple shroud, pinned together with safety pins. The fact that people who had IS6110 in their dental calculus or had osteological lesions were statistically correlated with these types of burials I do not believe suggests that there was a difference in burial practices for those who showed obvious signs of disease. A likely possibility is that more people with these sorts of diseases lived within the institutions.

IS6110 in environmental bacteria

One of the findings of this research that is of particular interest for molecular bioarchaeology moving forward, is the presence of IS6110 in a soil sample in Cemetery II which was taken from the matrix of Burial 5168. Müller et al. (2015) found the presence of IS6110 in other environmental *Mycobacteria* which are part of the *Mycobacterium tuberculosis* Complex (MTC) and which do not cause disease. The MTC is comprised of *Mycobaterium tuberculosis, Mycobacterium africanums, Mycobacterium bovis, Mycobacterium microti, Mycobacterium pinnipedii,, Mycobacterium canettii,* and *Mycobacterium caprae* (Witas et al. 2015:1733). Müller sequenced the results from her IS6110 PCR and found that bacteria in the soil and colonized the skeletons after death could be detected in her molecular bioarchaeological analysis. These results initially showed up as a positive IS6110 result, and without further sequencing would have appeared to have possibly come from tuberculosis. Bovine tuberculosis which usually comes from *Mycobacterium bovis* but which can also come from *M. tuberculosis* or *M. caprae*, can often be found in the soil (Santos 2015: 1). In North America, including rural Wisconsin, white-tailed deer can be carriers of these *Mycobacteria*, picked up from the soil while grazing, and the indirect transmission between them and cattle can then lead to either human transmission or to transmission to other cattle (Santos 2015: 14).

The result of a positive soil sample for IS6110 supports Muller's results. During life our bones are in a state of constant change from the circulation of water, minerals, and blood. The state of bones post-mortem is not all that different (López-Costas et al. 2016: 44). The bones that were used in this study had been previously washed and the samples of bone that were taken came from the cancellous bone after the initial layer of cortical bone had been scraped away by scalpel. However, while the body is decaying in the ground, it is left permeable and subject to different environmental influences (Bell 1990: 173). Diagenesis is the term used for post-mortem bio-chemical changes that occur in bone (López-Costas et al. 2016: 43). Although the teeth are generally less influenced by diagenesis, dental calculus is more vulnerable to external factors (Hollund et al. 2014). Diagenesis is heavily influenced by both the condition of the bone and the condition of the soil. The pH, the minerals present, temperature, and water levels all influence the uptake of nearby particles into the bone and the biomineralization process (Kendall et al. 2018: 28). Biomineralization, the process by which insoluble inorganic materials slowly replace the organic parts of bone, is influenced not only by the conditions, but also the composite makeup of the bone to begin with. It is for this reason that tooth enamel is far more resistant to biomineralization – it has a much higher mineral content than human bone does (Kendall et al. 2018: 27). It is entirely possible, especially due to the positive soil sample, that some of the IS6110 positives were due to diagenetic changes to the bone tissue and the introduction of environmental bacteria during decay. While in the case of IS6110, this was possibly compounded by the presence of IS6110 in the soil, the brucellosis results also showed no correlation.

The higher the mineral content and the smaller the pores in the bone, the less easy it is for microorganisms, ions, other minerals, or water to enter or leave the bones post-mortem. The type of bone also affects this, with thoracic bones being more porous and more prone to diagenetic alteration (López-Costas et al. 2016: 45). During the post-mortem interval, while the individual is interred, DNA is heavily subject to degradation. This, of course, is what makes extracting DNA from bone tissue so difficult. The temperature of the environment plays a strong role in the rate of decomposition of the DNA (Kendall et al. 2018: 30). Hydroxyapatite, the largest mineral component of bone, can have a protective effect on DNA preservation. The crystal complex of hydroxyapatite can shield the DNA from higher temperatures and higher water concentrations (Kendall et al. 2018: 30). It is for this reason that there is a high loss of DNA in the time after burial, but as further mineralization of the bone occurs, the process tapers off (Kendall et al. 2018: 30). This initial high loss of content is also due to the bacteria that are present in the human body, which rapidly break down the body's tissue as decomposition occurs. This stimulates a rapid chemical change in the post-mortem body (López-Costas et al. 2016: 45).

During the period of rapid loss of DNA in the years after burial, there is an opportunity for DNA from the surrounding environment to enter the bone. It is during this time, when there is a breakdown in the collagen and the bio organic material of bone and when the biomineralization process has not taken over, that the pores of entry into the bone are largest and the ions and organisms present within the burial are most likely to be able to enter (Kendall et al. 2018: 24). The positive IS6110 result from the soil sample means that at some point there were bacteria in the soil that contained the IS6110 repetitive element marker. As evidenced by the work of Kendall et al. (2018: 30), it is possible that the IS6110 and the bacterium from which it originated could have been present in the environment before the individual was buried, or it could have gotten into the soil from the individual's own biome.

Streptococcus pneumoniae

Of the three respiratory pathogens that were the focus of this study, only *Streptococcus pneumoniae* did not show any positive results. The reasons for this are unclear. One possible reason is that *S. pneumoniae* was just not present in that population during that time. Pneumonia, as discussed in Chapter 4, is the common name for a symptom, not for a specific pathogen. Pneumonia can be caused by any of the three bacteria that were included in this dissertation. *S. pneumoniae* is one of the more common opportunistic pathogens that can cause pneumonia in adults, but that is based on modern data. As was seen in the discussion of Mike Kranik, it is possible that the pneumonias that people were dying from came from various pathogens, not necessarily the *Streptococcus pneumoniae* bacterium.

Dental calculus as a non-destructive technique

One of the other main goals of this dissertation was to compare the use of dental calculus for examining archaeological DNA to the use of bone tissue, which is what has been more commonly used. None of the results showed a correlation between the dental calculus results and the vertebral bone tissue results, but it should be acknowledged that the vertebral bone tissue statistics are not strong enough to make it necessary for the dental calculus data to correlate with them in order to make them useful. The conclusions drawn from the data do not conclusively show that it is more beneficial to use dental calculus, but neither do they show that it is a less productive technique to use. While the osteological lesions were statistically significantly correlated with IS6110 based on the vertebrae but not based on the dental calculus data, this relationship was tenuous and showed no evidence of being causal. The dental calculus data were correlated with the presence of Category I material culture items in the burials. While this is also not necessarily causal, I believe that the use of dental calculus should be promoted and the use of bone tissue should be abandoned.

Due to the non-invasive nature of dental calculus collection, I believe that the benefits of using dental calculus are numerous. While the case could be made that the bone tissue results correlated more closely with the osteological lesions and therefore bone tissue should be used in preference to dental calculus, it should again be noted the statistical correlation between Category I grave goods and dental calculus and osteological lesions is worth noting. Ultimately, the identification of pathogenic DNA from dental calculus is new to the field of bioarchaeology, and because it is a non-destructive technique, it should be prioritized over any further destructive techniques. Using dental calculus in disease identification is not going to be possible with all diseases, only with those which produce a cough or vomitus. Tuberculosis, in its active form, will always produce a cough, and therefore is an ideal candidate for dental calculus research. We should assume that the actions that we take when dealing with any sort of human remains could add to the total pain experienced by the individual. In this way, using dental calculus is the more humane practice for protecting the individuals that we work with.

Infectious disease within the Milwaukee County Poor Farm Cemetery

As reported in Chapter 6, there was a significant correlation based on the results of the Fisher's Exact Test between a person having osteological lesions and having IS6110 in their DNA, although the predictive and causative value of this correlation was very low. This agreed with the results presented in my master's thesis and with the meta-analysis that I presented in

Chapter 4 (Werner 2015). The question then, is why there is no substantial correlation between IS6110 and tuberculosis lesions when we know that living people with tuberculosis have positive IS6110 and IS6110 can reliably be found in the tissue of mummies (Nerlich et al. 1997)? One possible explanation that has been discussed previously in this chapter is the possibility of transference of IS6110 from soil bacteria into archaeological samples. Another explanation lies in the work of Holloway et al. (2013: 15) who found that osteological lesions caused by tuberculosis can heal fully in a way that completely obliterates all signs of them.

Holloway et al. (2013) did not use any molecular biological methods in their work. They looked at different time periods related to the beginning of antibiotic usage to treat tuberculosis and the skeletal cases in their collection that fell within that time frame. A key component of their work is the presence of accurate medical records that went along with the collection. They found that whether through antibiotics or the body's own immune defenses, the bacteria were able to be cleared from the body's system and from the bone tissue (Holloway et al. 2013: 15). They found evidence of this occurring before the introduction of antibiotics. This is an important consideration both for the results from this dissertation and for other paleopathological studies in the future, because it is often assumed that where remodeling and lysis of the bone is still ongoing, the bacteria must still be present in some way. Holloway's (2013: 14) findings suggest that the infection, even prior to antibiotic usage, could be cleared in such a way that people with osteological lesions or with lesions not typically consistent with tuberculosis could still be considered as having had tuberculosis, and that there is a very good reason why there is no longer IS6110 in their tissue. Their other important finding is that lesions could be formed from tuberculosis infection on an individual's skeleton and then heal in a way that causes the vertebrae to look like they were infected by something other than tuberculosis, thus causing the observing osteologist to not consider the lesions as evidence of prior tuberculosis infection (Holloway et al. 2013: 15).

Looking through the lens of the deceased's suffering can show us the structural and contextual limitations that were placed upon them at the time of their death. The poor that lived with the stigma of infectious diseases in turn of the century Milwaukee were burdened not only by their health, but also by society's view of them and by the spatial-temporal boundaries of the County Hospital and the Milwaukee County Poor Farm. Whether or not this relationship is causal, there is a significant correlation between the type of burial and the presence of IS6110 in dental calculus and osteological lesions. This result speaks to the lives of the poor and the sick. The pain inflicted upon them came not only during their lives, but also from the manner of their burial and their forgotten names in death. While the details of their lives are still not given the care and attention that they deserve, my hope is that by providing further details about their lives and the potential stigma that they faced, future scholarship can continue the work of providing identity and post-mortem agency to the people of MCPFC.

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Appendix A

Comprehensive list of the material culture found in the burials included in this dissertation

Sample number	Burial ID	Sex	Age	Category	Safety pin	Glass	Buttons	Paper	Buckle	Clothing	Copper Wire	Ceramics	Iron
1	3039	M	Middle Age	One	Yes	No	No	No	No	No	No	No	No
2	2003	M	Young Adult	None	No	No	No	No	No	No	No	No	No
3	5035	F	Middle Age	None	No	No	No	No	No	No	No	No	No
4	5207	M	Middle Age	One	Yes	No	No	No	No	No	No	No	No
5	7230	NA	NA	Four	No	Yes	No	No	No	No	No	No	No
6	9263	M	Old Age	None	No	No	No	No	No	No	No	No	No
7	1009	M	Middle Age	One	Yes	Yes	No	No	No	No	No	No	No
8	1011	F	Middle Age	None	No	No	No	No	No	No	No	No	No
9	1012	M	Middle Age	None	No	No	No	No	No	No	No	No	No
10	1013	M	Middle Age	Two	Yes	No	Yes	Yes	Yes	No	No	No	No
11	1014	F	Old Age	Two	No	No	Yes	No	No	Yes	No	No	No
12	1015	M	Young Adult	None	No	No	No	No	No	No	No	No	No
13	1016	M	Middle Age	Two	No	No	Yes	No	No	No	No	No	No
14	1017	M	Middle Age	None	No	No	No	No	No	No	No	No	No
15	1021	M	Middle Age	None	No	No	No	No	No	No	Yes	No	No
16	1023	M	Middle Age	None	No	No	No	No	No	No	No	No	No
17	1024	M	Old Age	None	No	No	No	No	No	No	No	No	No
18	1029	M	Young Adult	None	No	No	No	No	No	No	No	No	No
19	1030	M	Middle Age	Two	No	No	Yes	No	No	No	No	No	No
20	1031	M	Middle Age	None	No	No	No	No	No	No	No	No	No
21	1035	M	Young Adult	One	Yes	Yes	Yes	No	No	No	No	No	No
22	1044	M	Middle Age	None	No	No	No	No	No	No	No	No	No
23	2005	M	Middle Age	None	No	No	No	No	No	No	No	No	No
24	2006	M	Young Adult	One	No	No	No	No	No	No	No	Yes	No
25	2007	M	Young Adult	None	No	No	No	No	No	No	No	No	No
26	2008	F	Young Adult	None	No	No	No	No	No	No	No	No	No
27	2012	M	Middle Age	None	No	No	No	No	No	No	No	No	No
28	2013	M	Young Adult	None	No	No	No	No	No	No	No	No	No
29	2015	M	Middle Age	None	No	No	No	No	No	No	No	No	No
30	2018	M	Middle Age	None	No	No	No	No	No	No	No	No	No
31	2025	M	Middle Age	One	Yes	Yes	No	No	No	No	No	No	No
32	2031	M	Middle Age	One	No	No	No	No	No	No	No	No	Yes

Sample number	Burial ID	Sex	Age	Category	Safety pin	Glass	Buttons	Paper	Buckle	Clothing	Copper Wire	Ceramics	Iron
34	2035	F	Young Adult	None	No	No	No	No	No	No	No	No	No
35	2038	M	Young Adult	None	No	No	No	No	No	No	No	No	No
36	2040	M	Middle Age	Two	Yes	No	Yes	No	No	Yes	No	No	No
37	2071	M	Young Adult	Two	Yes	No	Yes	No	No	Yes	No	No	No
38	2073	M	Old Age	None	No	No	No	No	No	No	No	No	No
39	2081	M	Middle Age	None	No	No	No	No	No	No	No	No	No
40	2129	F	Middle Age	Two	No	No	Yes	No	No	Yes	No	No	Yes
41	3026	M	Middle Age	None	No	No	No	No	No	No	No	No	No
42	3045	M	Middle Age	None	No	No	No	No	No	No	No	No	No
43	3051	M	Middle Age	None	No	No	No	No	No	No	No	No	No
44	3056	M	Middle Age	None	No	No	No	No	No	No	No	No	No
45	3057	F	Old Age	One	Yes	No	No	No	No	No	No	No	Yes
46	3062	M	Middle Age	One	Yes	Yes	No	No	No	No	No	No	No
47	3067	M	Old Age	None	No	No	No	No	No	No	No	No	No
48	5002	M	Middle Age	Two	No	No	No	No	No	Yes	No	No	No
49	5020	M	Middle Age	None	No	No	No	No	No	No	No	No	No
50	5092	M	Middle Age	None	No	No	No	No	No	No	No	No	No
51	5095	M	Middle Age	None	No	No	No	No	No	No	No	No	No
52	5101	M	Young Adult	None	No	No	No	No	No	No	No	No	No
53	5107	M	Middle Age	Two	Yes	No	Yes	No	No	Yes	No	No	No
54	5134	M	Middle Age	None	No	No	No	No	No	No	No	No	No
55	5166	M	Middle Age	None	No	No	No	No	No	No	No	No	No
56	5186	M	Middle Age	None	No	No	No	No	No	No	No	No	No
57	5190	M	Old Age	None	No	No	No	No	No	No	No	No	No
58	5211	M	Middle Age	One	Yes	No	No	No	No	No	No	No	No
59	5228	M	Old Age	None	No	No	No	No	No	No	No	No	No
60	5235	M	Middle Age	None	No	No	No	No	No	No	No	No	No
61	5238	F	Old Age	One	Yes	No	No	No	No	No	No	No	No
62	7042	M	Old Age	None	No	No	No	No	No	No	No	No	No
63	7070	F	Young Adult	None	No	No	No	No	No	No	No	No	No
64	7098	F	Old Age	None	No	No	No	No	No	No	No	No	No
66	7172	F	Middle Age	None	No	No	No	No	No	No	No	No	No

Sample number	Burial ID	Sex	Age	Category	Safety pin	Glass	Buttons	Paper	Buckle	Clothing	Copper Wire	Ceramics	Iron
67	7185	M	Middle Age	None	No	No	No	No	No	No	No	No	No
68	8016	M	Young Adult	None	No	No	No	No	No	No	No	No	No
69	8017	M	Middle Age	None	No	No	No	No	No	No	No	No	No
70	8043	M	Middle Age	Two	No	No	Yes	No	No	Yes	No	No	No
71	8065	M	Middle Age	None	No	No	No	No	No	No	No	No	No
72	8069	M	Middle Age	None	No	No	No	No	No	No	No	No	No
73	8074	M	Middle Age	None	No	No	No	No	No	No	No	No	No
74	8100	M	Old Age	One	Yes	No	No	No	No	No	No	No	No
75	8120	M	Middle Age	None	No	No	No	No	No	No	No	No	No
76	8174	M	Middle Age	Four	Yes	Yes	No	No	No	No	No	No	No
78	9215	M	Old Age	None	No	No	No	No	No	No	No	No	No
79	9245	M	Old Age	One	No	No	No	No	No	Yes	No	No	No
80	9263	M	Old Age	Four	Yes	No	No	No	No	No	No	Yes	No
81	9280	M	Middle Age	None	No	No	No	No	No	No	No	No	No
82	9291	M	Young Adult	None	No	No	No	No	No	No	No	No	No
83	9309	M	Middle Age	None	No	No	No	No	No	No	No	No	No
84	9314	F	Young Adult	One	Yes	No	No	No	No	No	No	No	No
85	9315	F	Middle Age	None	No	No	No	No	No	No	No	No	No
86	9317	M	Middle Age	None	No	No	No	No	No	No	No	No	No
87	9333	F	Young Adult	Three	Yes	No	No	No	No	Yes	No	No	No
88	9344	M	Middle Age	Two	No	No	Yes	No	No	No	No	No	No
89	9346	M	Middle Age	Two	Yes	No	Yes	No	No	No	No	No	No

Appendix B

Comprehensive list of the bioarchaeological and molecular biological results included in this dissertation

Sample number	Burial ID	Lesions Present	DNA extracted	IS6110 Vert	IS6110 Calculus	IS6501 Calculus	IS6501 Vert	Pneum. Calculus	Pneum Vert	Calculus collected
1	3039	Yes	Yes	Yes	No	No	No	No	No	Yes
2	2003	Yes	Yes	Yes	No	No	No	No	No	Yes
3	5035	Yes	Yes	No	No	No	No	No	No	Yes
4	5207	Yes	Yes	No	No	No	No	No	No	Yes
5	7230	Yes	Yes	No	Yes	No	No	No	No	Yes
6	9263	Yes	Yes	Yes	No	No	No	No	No	Yes
7	1009	Yes	Yes	Yes	NA	NA	No	NA	No	No
8	1011	No	Yes	Yes	NA	NA	No	NA	No	No
9	1012	Yes	Yes	No	NA	NA	No	NA	No	No
10	1013	No	Yes	Yes	NA	NA	No	NA	No	No
11	1014	No	Yes	No	No	Yes	No	No	No	Yes
12	1015	No	Yes	No	No	No	No	No	No	Yes
13	1016	No	Yes	No	NA	NA	No	NA	No	No
14	1017	No	Yes	Yes	No	No	No	No	No	Yes
15	1021	No	Yes	No	No	No	Yes	No	No	Yes
16	1023	No	Yes	No	No	No	No	No	No	Yes
17	1024	No	Yes	No	NA	NA	No	NA	No	No
18	1029	No	Yes	No	NA	NA	No	NA	No	No
19	1030	No	Yes	No	No	No	No	No	No	Yes
20	1031	No	Yes	No	NA	NA	No	NA	No	No
21	1035	No	Yes	Yes	Yes	No	No	No	No	Yes
22	1044	No	Yes	Yes	No	No	No	No	No	Yes
23	2005	No	Yes	No	No	No	No	No	No	Yes
24	2006	Yes	Yes	No	No	No	Yes	No	No	Yes
25	2007	No	Yes	No	No	Yes	Yes	No	No	Yes
26	2008	No	Yes	No	No	No	No	No	No	Yes
27	2012	No	Yes	No	NA	NA	No	NA	No	No
28	2013	No	Yes	No	NA	NA	No	NA	No	No
29	2015	No	Yes	No	NA	NA	No	NA	No	No

30	2018	No	Yes	No	No	Yes	No	No	No	Yes
Sample number	Burial ID	Lesions Present	DNA extracted	IS6110 Vert	IS6110 Calculus	IS6501 Calculus	IS6501 Vert	Pneum. Calculus	Pneum Vert	Calculus collected
31	2025	No	Yes	No	No	No	No	No	No	Yes
32	2031	No	Yes	No	NA	NA	No	NA	No	No
34	2035	No	Yes	No	NA	NA	No	NA	No	No
35	2038	No	Yes	Yes	No	No	No	No	No	Yes
36	2040	No	Yes	No	NA	NA	No	NA	No	No
37	2071	No	Yes	No	No	No	No	No	No	Yes
38	2073	No	Yes	No	No	No	No	No	No	Yes
39	2081	No	Yes	No	NA	NA	No	NA	No	No
40	2129	No	Yes	No	No	No	No	No	No	Yes
41	3026	No	Yes	No	No	No	No	No	No	Yes
42	3045	No	Yes	No	No	No	No	No	No	Yes
43	3051	No	Yes	No	No	No	No	No	No	Yes
44	3056	No	Yes	No	NA	NA	No	NA	No	No
45	3057	No	Yes	No	NA	NA	No	NA	No	No
46	3062	No	Yes	No	Yes	No	No	No	No	Yes
47	3067	No	Yes	No	No	No	No	No	No	Yes
48	5002	No	Yes	No	No	No	No	No	No	Yes
49	5020	No	Yes	No	NA	NA	No	NA	No	No
50	5092	No	Yes	No	No	No	No	No	No	Yes
51	5095	No	Yes	No	No	No	No	No	No	Yes
52	5101	No	Yes	No	NA	NA	No	NA	No	No
53	5107	No	Yes	No	No	No	No	No	No	Yes
54	5134	No	Yes	No	No	No	No	No	No	Yes
55	5166	No	Yes	No	NA	NA	No	NA	No	No
56	5186	No	Yes	No	NA	NA	No	NA	No	No
57	5190	No	Yes	No	NA	NA	No	NA	No	No
58	5211	No	Yes	No	NA	NA	No	NA	No	No
59	5228	No	Yes	No	NA	NA	No	NA	No	No
60	5235	No	Yes	No	No	Yes	No	No	No	Yes

Sample number	Burial ID	Lesions Present	DNA extracted	IS6110 Vert	IS6110 Calculus	IS6501 Calculus	IS6501 Vert	Pneum. Calculus	Pneum Vert	Calculus collected
61	5238	No	Yes	No	NA	NA	No	NA	No	No
62	7042	No	Yes	No	NA	NA	No	NA	No	No
63	7070	No	Yes	No	No	No	No	No	No	Yes
64	7098	No	Yes	No	NA	NA	No	NA	No	No
66	7172	No	Yes	No	No	No	No	No	No	Yes
67	7185	No	Yes	No	NA	NA	No	NA	No	No
68	8016	No	Yes	No	No	No	No	No	No	Yes
69	8017	No	Yes	No	No	No	No	No	No	Yes
70	8043	No	Yes	No	NA	NA	No	NA	No	No
71	8065	No	Yes	No	NA	NA	No	NA	No	No
72	8069	No	Yes	No	NA	NA	No	NA	No	No
73	8074	No	Yes	No	NA	NA	No	NA	No	No
74	8100	No	Yes	No	No	No	No	No	No	Yes
75	8120	No	Yes	No	No	No	No	No	No	Yes
76	8174	No	Yes	No	NA	NA	No	NA	No	No
78	9215	No	Yes	No	No	No	No	No	No	Yes
79	9245	No	Yes	No	NA	NA	No	NA	No	No
80	9263	No	Yes	No	No	No	No	No	No	Yes
81	9280	No	Yes	No	No	No	No	No	No	Yes
82	9291	No	Yes	Yes	No	No	No	No	No	Yes
83	9309	No	Yes	No	No	No	No	No	No	Yes
84	9314	No	Yes	No	NA	NA	No	NA	No	No
85	9315	No	Yes	No	NA	NA	No	NA	No	No
86	9317	No	Yes	No	NA	NA	No	NA	No	No
87	9333	No	Yes	No	NA	NA	No	NA	No	No
88	9344	No	Yes	No	NA	NA	No	NA	No	No
89	9346	No	Yes	No	No	No	No	No	No	Yes
5168	NA	NA	NA	NA	Yes	No	No	No	No	NA
7172	NA	NA	NA	NA	No	No	No	No	No	NA
8174	NA	NA	NA	NA	No	No	No	No	No	NA

Appendix C

The results of the DNA analysis with each individual person in the rows and whether there was evidence of the three diseases in either their bone or their dental calculus in the columns. Rows were highlighted if the bone and the dental calculus results agree.

		Vertebrae			Dental Calculus		
Burial ID	Lesions Present	Tuberculosis	Brucellosis	Pneumonia	Tuberculosis	Brucellosis	Pneumonia
3039	X	X					
2003	X	X					
5035	X						
5207	X						
7230	X				X		
9263	X	X					
1009	X	X					
1011		X					
1012	X						
1013		X					
1014						X	
1015							
1016							
1017		X					
1021			X				
1023							
1024							
1029							
1030							
1031							
1035		X			X		
1044		X					
2005							

2006	X		X				

Burial ID	Lesions Present	Tuberculosis	Brucellosis	Pneumonia	Tuberculosis	Brucellosis	Pneumonia
2007			X			X	
2008							
2012			X				
2013							
2015							
2018						X	
2025							
2031							
2035							
2038		X					
2040							
2071							
2073							
2081							
2129							
3026							
3045							
3051							
3056							
3057							
3062					X		
3067							
5002							
5020							
5092							

5095							
Burial ID	Lesions Present	Tuberculosis	Brucellosis	Pneumonia	Tuberculosis	Brucellosis	Pneumonia
5101							
5107							
5134							
5166							
5186							
5190							
5211							
5228			X				
5235						X	
5238			X				
7042							
7070							
7098							
7172							
7185							
8016							
8017							
8043							
8065							
8069							
8074							
8100							
8120							
8174							
9215							

9245							

Burial ID	Lesions Present	Tuberculosis	Brucellosis	Pneumonia	Tuberculosis	Brucellosis	Pneumonia
9263							
9280							
9291		X					
9309							
9314							
9315							
9317							
9333							
9344							
9346							

Helen M. Werner

Curriculum vitae

RESEARCH INTERESTS

Paleomicrobiology, Midwestern Archaeology, Historic Cemeteries, Bayesian Data Analysis

EDUCATION

2019 Doctoral Degree, Anthropology, University of Wisconsin-Milwaukee

2015 Masters of Science, Anthropology, University of Wisconsin-Milwaukee

2008 Bachelors of Science, Biology, University of Wisconsin, Madison

Educational Honors and Awards: UW-Milwaukee Graduate School travel grants, Lambda Alpha Anthropology Honors Society

SELECTED GRANTS

Submitted DDRI Biological Anthropology, National Science Foundation

2018 Anthropology Dissertation Completion Award

2017 DA Leonard Family Preliminary Dissertation Research Award

PRESENT POSITIONS

Visiting Curator of Bioarchaeology at Beloit College

Instructor, Blackhawk Technical College, Advanced Anatomy

Archaeologist, Historic Research Management Services, University of Wisconsin-Milwaukee

PREVIOUS POSITIONS

Research and Management Experience

2015 – 2017 Research Specialist, Waisman Center, University of Wisconsin, Madison

2012 Research Technician, Department of Pathology, University of Wisconsin, Madison

2010 – 2012 Research Specialist, Department of Medicine, University of Wisconsin, Madison

2008 – 2009 Associate Research Specialist, Department of Obstetrics and Gynecology, University of Wisconsin, Madison

2007 – 2008 Research Assistant, Department of Obstetrics and Gynecology, University of Wisconsin, Madison

2006 – 2007 Research Assistant, Department of Biochemistry, University of Wisconsin, Madison

Archaeological Experience and Affiliations (Major Projects Only)

2018 University of Wisconsin-Milwaukee Cultural Resource Management

2017 Archaeologists Qualified to Work within the Boundaries of a Human Burial Site & Excavate Human Burials for the Wisconsin Historical Society

2017 Skeletal Analyst for the Wisconsin Historical Society

2016 Odyssey Field School of Forensic Anthropology and Archaeological Excavation, Limassol, Cyprus

Teaching Experience

Fall 2018 Professor, Department of Biological Sciences, University of Wisconsin-Milwaukee for the lecture Anatomy and Physiology I.

Spring 2018 Visiting Faculty, Department of Anthropology, Beloit College, for the courses: Biological Methods for the Anthropologist, The Human Animal

2017 – 2018 Lead Teaching Assistant and Laboratory Instruction Coordinator, Department of Biological Sciences, University of Wisconsin-Milwaukee, for the course Anatomy and Physiology I under Andrew Petto

2016-2018 Instructor, Department of Continuing Education, Madison College, for the course Intermediate Applied Statistics.

2015-2017 Instructor, Department of Continuing Education, Madison College, for the course Introduction to Applied Statistics.

2013 – 2017 Teaching Assistant, Department of Anthropology, University of Wisconsin-Milwaukee, for the course Anthropological Statistics under Joseph P. Gray using the statistics program R.

2013 – 2017 Teaching Assistant, Department of Biological Sciences, University of Wisconsin-Milwaukee, for the course Anatomy and Physiology I under Andrew Petto.

2013 – 2014 Writing Center Tutor, Online Writing Lab, University of Wisconsin Colleges.

EDITING AND RELATED EXPERIENCE

Statistical Projects

2018 Shannon K Freire, A Public Humanity: The application of isotopic analysis to the intersection between body and law at the Milwaukee County Institution Grounds Poor Farm Cemetery, PhD Dissertation

2017 Krueger, Diane, et al. "Total body less head measurement is most appropriate for lean mass assessment in adults." *Journal of Clinical Densitometry* 20.1: 128-129.

2015 Jamie Patrick Henry, A Preliminary Museological Analysis of the Milwaukee Public Museum's Euphrates Valley Expedition Metal Collection, Masters Thesis

2015 Siglinsky, Ellen, et al. "Effect of age and sex on jumping mechanography and other measures of muscle mass and function." *Journal of musculoskeletal & neuronal interactions*15.4: 301.

Educational Development and Outreach

2015 – Present Guest speaker for Women in Science and Engineering at UW Platteville

2015 – Present Reviewer, McGraw Hill LearnSmart, Window on Humanity

2011 – 2012 Educational Content Creator, Keas.com

PUBLICATIONS

*Publishing under the name Helen Holden prior to October 1st, 2011

n.d. **Helen M. Werner**, Katelyn K. Tillman, Houri Vorperian. Hyoid growth and development from birth to 19 years using 3D imaging techniques. *Submitted to Archives of Oral Biology.*

n.d. **Helen Werner**, Jessica Skinner. Changes in Bone Density during the Post-Mortem Interval for the individuals of the Milwaukee County Poor Farm Cemetery. *Submitted to Archaeological Sciences.*

n.d. **Helen Werner**, Joseph P Gray, Patricia Richards. A Meta-Analysis of IS6110 and Tuberculosis Skeletal Lesions: an update to the prior with the Milwaukee County Poor Farm Cemetery data. *Submitted to Statistics in Biosciences.*

2017 Michael Kelly, Houri Vorperian, Yuan Wang, Katelyn Tillman, **Helen Werner**, Moo Chung, Lindell Gentry. Characterizing mandibular growth and development using three-dimensional imaging techniques and anatomic landmarks. *Archives of Oral Biology*.

2016 Ellie Fisher, Diane Austin, **Helen Werner**, Ying Ji Chuang, Edward Bersu, Houri Vorperian. Hyoid bone fusion and bone density across the lifespan: prediction of age and sex. *Submitted to Forensic Science, Medicine, and Pathology.*

2015 **Helen Werner**. Molecular Identification of *Mycobacterium tuberculosis* in the Milwaukee County Institution Grounds Cemetery, *Masters Thesis*.

2015 Dr. Zhengying Guo , Ms. Rebecca Baus , **Ms. Helen Werner** , Prof. William Rehrauer , Dr. Ricardo Lloyd. INSM1: a Novel Immunohistochemical and Molecular Marker for Neuroendocrine and Neuroepithelial Neoplasms. *Molecular Pathology*.

2010 Jennifer A.A. Gubbels, Mildred Felder, Sachi Horibata, Jennifer A. Belisle, **Helen Holden**, Sarah Petrie, Martine Migneault, Claudine Rancourt, Joseph Conner, and Manish S. Patankar. MUC16 inhibits the binding of NK cells to ovarian tumor targets. *Molecular Cancer*.

SELECT PROFESSIONAL PAPERS AND POSTERS

*Publishing under the name Helen Holden prior to October 1st, 2011

2018 Werner, Helen and Alexander Anthony

Society for Historical Archaeology Annual Meeting, New Orleans, LA

Presence of Pathological Tuberculosis in Relation to Perimortem Institutionalization at the Milwaukee County Poor Farm Cemetery

2016 Werner, Helen

Molecular Identification of Mycobacterium tuberculosis in the Milwaukee County Institution Grounds Cemetery. American Association of Physical Anthropologists Annual Meeting, Atlanta, GA.

2015 Werner, Helen

The use of IS6110 in the identification of Mycobacterium tuberculosis in the Milwaukee County Institution Grounds Cemetery. Midwest Archaeology Conference, Milwaukee, WI.

2015 Werner, Helen

Molecular Identification of *Mycobacterium tuberculosis* in the Milwaukee County Institution Grounds Cemetery. Society for American Archaeology Annual Conference, San Francisco, CA.

2014 Werner, Helen

Molecular Identification of *Mycobacterium tuberculosis* in the Milwaukee County Institution Grounds Cemetery. Anthropology Student Union Colloquium, Milwaukee, WI.

PROFESSIONAL MEMBERSHIP

Registered Professional Archaeologist (RPA #34142507)

Society for American Archaeology

Society for Historical Archaeology

Lamda Alpha Anthropology Honors Society

American Association of Physical Anthropologists

American Association of University Women