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PALEOPATHOLOGY AND PUBLIC HEALTH IN "AMERICA'S HEALTHIEST CITY": A COMPARATIVE STUDY OF HEALTH FROM THE MILWAUKEE COUNTY INSTITUTION GROUNDS CEMETERY

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PALEOPATHOLOGY AND PUBLIC HEALTH IN "AMERICA'S HEALTHIEST CITY": A COMPARATIVE STUDY OF HEALTH FROM THE MILWAUKEE COUNTY INSTITUTION GROUNDS CEMETERY

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By

Colleen F. Milligan

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ABSTRACT

PALEOPATHOLOGY AND PUBLIC HEALTH IN "AMERICA'S HEALTHIEST CITY": A COMPARATIVE STUDY OF HEALTH FROM THE MILWAUKEE COUNTY INSTITUTION GROUNDS CEMETERY

By

Colleen F. Milligan

Milwaukee was a rapidly industrializing urban center in the late nineteenth and early twentieth centuries. An expanding population generated social problems, including increasing numbers of homeless people, the chronically ill, and those unable to provide for themselves. By 1880, the county established various institutions to house orphans, the poor, people with a chronic debilitating illness, or with a physical or mental disability. Established to accompany Milwaukee's various institutions, the Milwaukee County Institution Grounds (MCIG) became the burial grounds for those individuals who died in the institutions, the unidentified from the coroner's office, and those unable to afford burial fees from the city at large.

Between 1991 and 1992, a portion of the MCIG cemetery was excavated. The excavated section, dated to between 1882-1925, yielded a total of 1,649 burials consisting of 1,061 adult remains and 588 classified as subadult burials. This study examines the health of the most vulnerable members of an urban center once given the distinction of 'America's Healthiest City'. The goals of the study include an expansion of the archaeological work concerning the impact of the social environment of the time period. Furthermore, the study addresses the health of the excavated remains and looks specifically at the city's efforts towards public health initiatives and the impact of such efforts on those interred at the MCIG cemetery. Paleopathological observations of

specific and nonspecific indicators of stress are used to establish both common and age-specific prevalence rates for the sample, and are compared to available historical archives. In addition, the study focuses on the comparison of the MCIG sample with similar samples including both indigent and community cemeteries. The comparative samples are the Dunning Poorhouse Cemetery (Chicago, IL), the Monroe County Poorhouse Cemetery (Rochester, NY), and the Voegtly Cemetery (Pittsburgh, PA). These comparisons serve as the basis from which to establish the relative health of the indigent within the city of Milwaukee.

ACKNOWLEDGMENTS

The MCIG skeletal analysis has spanned almost 20 years of research on over one thousand individuals from Milwaukee, WI, and summarily amassed well over 10,000 pages of data. I have been involved in the research efforts for 8 of those years. I have taken pride in being able to contribute to a project of this size, but I am also well aware of how many people it takes to undertake such an endeavor. I would like to acknowledge those who have also been part of the team, and in some cases continue to contribute, to the MCIG project: Sean Dougherty; Lauren (Devitt) Forsythe; Ryan Patalita; Sarah Becker; Emma Lee; Julianne Ivany; Jessica Zotcavage; Dr. Kathy Schrube; Tim Prindville; Laura Hutchinson, Maura Polli; Brenda Buchanon; Steven Trage; Brian Sauer; Corey Schneider; Kathy Rognsvoog; and Drs. Caesar Gonzalas and Donald Pruse.

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Although I acknowledged each individually, I have to collectively thank my "personal" research team who assigned themselves the task of asking me what I needed in order to do my work – whether it was a place to sleep, a car to get around, a pick-up at the train station, or assistants for research trips. Total count – we took 9,448 pictures, digitizing roughly 50 years of historical records from several institutions, and transcribed thousands of pages of data. Thanks again Mom, Dad, Erin, and Jon.

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Introduction

Between 1991 and 1992, a portion of the Milwaukee County Institution Grounds (MCIG) cemetery #2 was excavated by the Great Lakes Archaeological Research Center, Inc. (Richards and Kastell 1993; Richards 1997). The cemetery, the second to be established on County Grounds, was in use from August 1882 until July 1925 (Richards and Kastell 1993; Richards 1997). Those interred in the burial ground included residents from Milwaukee's various institutions, members of society unable to afford burial fees, as well as, unidentified and unknown remains from the coroner's office. The excavated remains, although representing the entire time during which the cemetery was in operation, include only 1,649 individuals from the 5,288 listed in the burial record for cemetery #2 (*Register of Burial 1882-1925*).

The presence and impact of communicable diseases was a major health concern during the time period represented by the cemetery. Cities across America were engaged in discussions on how best to improve the urban environment and how to combat the epidemic and endemic diseases that arose in these environments (Duffy 1978). The need for public health reform also coincided with the need to address urban poverty as the contagions present in the cities affected all social classes. Volunteer groups, often the primary catalysts for reform, focused much of their attention on the conditions of the poor (Duffy 1978).

The city of Milwaukee, like most major cities, struggled with the need to address both the city's worsening sanitary situation and increasing poverty. Poor sanitation and overcrowding created environments for the spread of disease and the impact of communicable diseases in turn increased the number of residents living in impoverished conditions. The Milwaukee County Institutional Grounds Cemetery represents the burial grounds for many of the city's impoverished. Representing both an institutional and public cemetery, those interred on county grounds lived during a timeframe where the city's increasing efforts towards public health reform was a prominent concern. As pointed out by Steckel and Rose in *The Backbone of History* (2002), the health of a population is closely linked to social, economic, and political forces. It can be both a catalyst for change and a major factor in the growth and development of any population. This dissertation focuses on the relations among skeletal health, urbanization, and public health initiatives.

The Concept of Health in Bioarchaeological Studies

Within physical anthropology, studies often focus on how individuals and the communities they live in adapt biologically to various stressors. Anthropological studies of health have traditionally focused on the identifiable shifts between subsistence strategies and settlement patterns. However, the evidence available for addressing these changes is often limited to that which can be gleaned from archaeological investigations. For example, the connection between agriculture and an increase in sedentism and population density can be studied in relation to increases in prevalence rates of infection within varying populations (Stuart-Macadam 1992; Ubelaker 1992). The effects of a number of different factors, such as diet, environment, behavioral adaptations, and disease, are pulled from both the skeletal remains available to researchers and the archaeological context in which they are found.

Research on the health of a population is often centered on how populations respond to both long-term and episodic stressors, as well as, those associated with certain disease processes. A review of "health-related" literature in the American Journal of Physical Anthropology shows concern for four major areas of research: disease studies; growth and development; examinations of physiological stress; and diet. For example, Buzon and Judd (2008) outline several indicators of physiological stress to assess the health of individuals from different burial contexts at the Nubian site of Kerma. These indicators include evidence for cribra orbitalia, dental enamel hypoplasias, tibial osteoperiostitis, and femur length.

The research conducted in regards to issues of health in archaeological contexts focuses on skeletal indicators commonly associated with stress. Mays *et al.* (2008), in a regional study, looked at the transition from rural populations to large urban centers in 19th century England. Based on the historical emphasis on living conditions in the growing cities, the study evaluated differences in endochrondral growth between comparable subadults in a rural and urban burial context. While the results showed no significant differences, it was acknowledged that subadult health is more accurately assessed in archaeological populations when growth studies are combined with studies of both specific and non-specific skeletal markers of stress.

The importance of such research lies not in what is observed, but how these observations are interpreted. In a similar fashion, Goodman and Rose (1990) reviewed enamel development in human teeth and examined some possible causes of enamel hypoplasias as indicators of episodic stress. These indicators of stress, like the ones mentioned above, are often used by anthropologists to draw conclusions about the health of human populations in relation to adaptive and socioeconomic processes (Goodman *et al.* 1988). The comparison of these variables with other samples across geographic and temporal space expands the context in which any discussion of health is situated.

Paleopathology and Disease Studies

The study of disease processes from skeletal remains is an important component for studies of past health. The diagnosis and interpretation of skeletal indicators of pathology, however, is a problematic area for anthropologists. These indicators can derive from a number of causal factors encountered during the life of the individual, such as age-related changes, behavioral modifications, trauma, or disease. However, as is often noted in published literature, the skeletal system is not easily affected nor impacted. For example, looking only at infectious diseases and their impact on bones, anthropologists are often limited in the diseases to be considered. The diseases that have the potential to impact the skeletal system are often indicative of a chronic illness. While both the absence and presence of such disease markers are meaningful to any study of paleopathology, their presence can be indicative of the ability of the body's immune system to sustain a resistance to the disease (Ortner 2003; Wood *et al.* 1992).

Even when such diseases are noted in a skeletal sample, anthropologists often struggle with the concept of making a differential diagnosis. There are only so many ways in which the skeletal system will exhibit pathological changes, such as bone loss or bone formation. However, there is considerable overlap between the ways in which the skeletal system can be affected and the diseases that cause these changes. The identification of different disease processes has included both contributions from the biological evidence in archaeological samples, and that derived from paleoepidemiological models for disease in specific regions. These diagnoses are further narrowed by the inclusion of factors such as age of onset and biocultural environment, which includes the absence or presence of the pathogen within a particular region (Buikstra and Cook 1980).

Paleopathological identification requires knowledge about the pathogenesis and epidemiology of the diseases in question (Ortner 2003). In order to establish appropriate criteria from which anthropological investigations can proceed, Buikstra and Cook (1980) outlined a model for testing hypotheses about specific diseases. Their model focuses on the fact that not every disease leave traces on the skeletal system, and those that do will not always show up in the archaeological record. Infections that tend to be chronic, rather than acutely fatal, are over-represented in archaeological samples (Aufderheide and Rodríguez-Martín 1998). As suggested by Wood et al. (1992), the presence of skeletal indicators of infectious processes may actually reflect an individual's increased ability to resist the infectious agent despite its presence in an archaeological sample.

The Buikstra and Cook model proposes three stages from which to document the skeletal responses that are present. The first stage is the development of a research model for a differential diagnosis. The second stage includes observations as to the bony responses and reactions to either stress or disease on all skeletal elements present. The third stage asks the researcher to compare the model (and hypotheses) to known empirical evidence for the manifestations associated with a specific disease (Buikstra and Cook 1980). In their opinion, a differential diagnosis depends upon the researchers' ability to identify the key features of the diseases in question that separate one pathogen from another (Buikstra and Cook 1980).

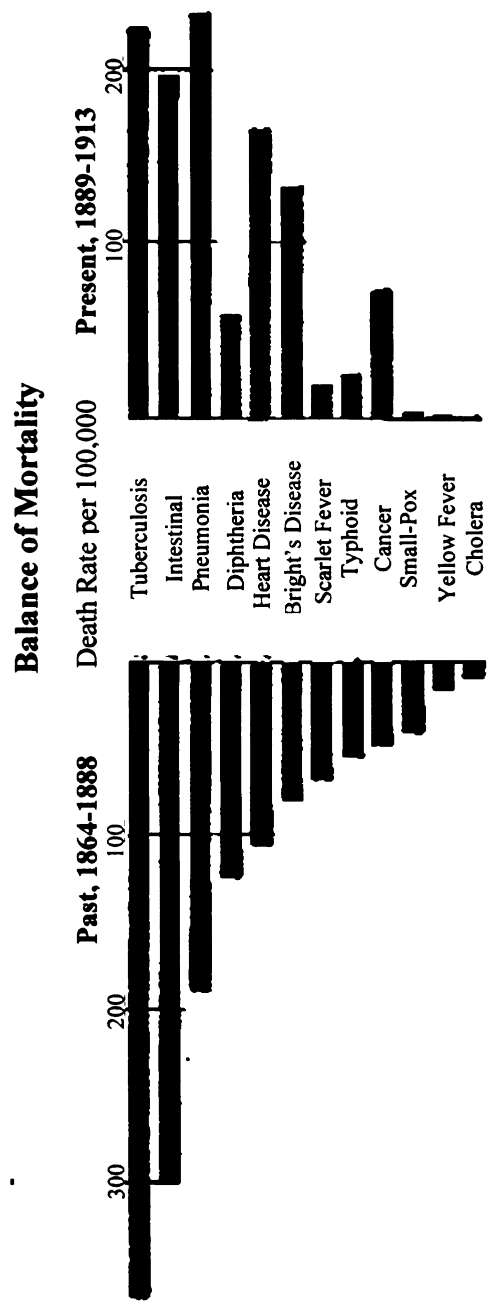
In light of the concern over overlapping etiologies, most researchers strive to first examine broader categories of disease, such as general infection, with the intent of increasing the accuracy of the resulting conclusions drawn from any given sample. Differential diagnoses drawn from these general conclusions rely on descriptions of both the type and location of bony responses to disease and stress (Ortner 2003). While non-specific indicators of stress give a general overview of the impact of stress on a population, the patterns and indicators associated with a number of specific diseases can shed light on the health of both populations and individuals.

Public Health and the Epidemiological Transition

Disease studies often concern two related transitions: the demographic transition and the epidemiological transition. The demographic transition refers to a theoretical model of declines in mortality, fertility, and population growth following the industrial revolution (Gage 2005). Within physical anthropology, the concern for such a transition would be its impact on mortality trends and the impact of both infectious and degenerative diseases. Like the switch from hunter-gatherer subsistence strategies to agriculture, the rise of industry in America's cities shows an associated shift of people out of the countryside and into the urban centers. This shift again changed the environmental context in which populations found themselves and brought with it new cultural factors, both positive and negative. The mortality and fertility trends that accompanied the change are often seen as evidence of a biological response to new cultural stressors (Omran 1977).

With the use of historical records and archival research, mortality trends also can be examined for specific cause of death information or cause-specific mortality (Gage 2005). The search for cause-specific mortality trends is a primary component of studies related to the evolution of medicine, and by extension, the evolution of pathogens. The most recent epidemiological transition refers to a rank ordering of cause of death where more recent trends have shown degenerative diseases replacing infectious diseases as more common causes of death (Barrett *et al.* 1998; Gage 2005; Omran 1977). Figure 1 shows a 1921 summary of the major causes of death over 50 years in the United States. The chart shows the relative decrease in infectious diseases and increase in degenerative diseases in several large American cities. Most noticeably, the death rate (per 100,000) rises for both heart disease and cancers while declining for all infectious diseases except pneumonia.

Figure 1: "American Public Health – Past and Present 1864 – 1913", source *A Half Century of Public Health* (1921)



Nineteenth century America saw major disruptions in their cities due to the impact of virulent epidemics (Leavitt 1978). By this time, the number of individuals residing in or around urban areas was greater than those living in rural communities. Rapid population growth and overcrowding overwhelmed the sanitation systems in cities. As a result, the impact of disease on urban populations reached epidemic proportions. The emphasis placed on the public health movement was a direct result of the attempt to mitigate the impact of disease in America's cities. City health departments were strengthened and charged with the task of controlling infectious diseases (Leavitt 1978). By the late 19^{th} century, city health officials pushed for mass public health initiatives, such as the mass vaccination of city residents against the small pox pathogen or the isolation of tuberculosis patients in institutionalized care (Fox 1978). Duffy (1978) points out that public health policies became a primary focus of the socio-political context of cities, and hence are prominently discussed in urban history studies.

Studies of Health from Human Skeletal Remains

In recent years, more attention has been given to how health is addressed from human skeletal remains. Publications, such as Steckel and Rose's *The Backbone of History* (2003), and the Global History of Health Project (found at http://global.sbs.ohio-state.edu) have actively sought to consolidate skeletal studies pertaining to health. The consolidation of data provides the context to assess long-term trends in the evolution of health based on skeletal indicators of health (Steckel *et al.* 2002a). The studies included in both of these projects span prehistoric and historic time periods, and geographically cover both the Western Hemisphere and Europe. When looking at the evolution of health, the research questions that are posed look at the adaptability of humans to the environment around them (Steckel *et al.* 2002b).

As stated earlier, examinations of health are influenced by social, political, and cultural factors. However, prior to the 19th century, the availability of historical data on populational health is limited (Steckel *et al.* 2002b). The use of skeletal studies addresses some of the gaps in this knowledge by providing alternate forms of evidence for studies of human health. In particular, measures that address the growth and development of individual remains, the presence of trauma, and identifiable disease processes lend evidence to stressors that may have affected individual health during the course of their lifetime.

Introduction to Research Goals

Historical studies provide an opportunity for researchers to use multiple lines of evidence to discern information about past. In particular, the inclusion of multiple sources that vary in type and scope strengthens the conclusions that can be drawn from skeletal samples. The goals of this study address the relative health of skeletal remains from the Milwaukee County Institution Grounds (MCIG), combining the skeletal analysis with available archaeological and historical evidence. The research questions look at those areas of analysis that would contribute the most to an understanding of the life and death of those interred on county grounds.

The research goals for this dissertation are as follows:

1) The archaeological analysis focused on establishing the context in which the MCIG remains were situated, namely as part of the larger community surrounding the city of Milwaukee. This study seeks to expand upon the archaeological work by focusing on the sociopolitical context at the time the cemetery was in operation and using available historical records to identify the public health initiatives that may have impacted the health of those interred on county grounds.

2) The study uses the skeletal analysis from the MCIG cemetery to address the health of residents of a city once deemed "America's Healthiest" (Leavitt 1982). The goal is to use several skeletal indicators of growth and development and pathology to correlate the city's efforts towards public health initiatives and the impact such efforts may have had on both adult and subadult individuals from the MCIG cemetery.

3) The analysis of health from the MCIG remains is relative to what is observed in other samples. The third goal is to compare the sample used from the MCIG cemetery to similar skeletal samples. The study will look at both the observed health and the differences in how health is assessed in each sample, to assess the significance of the presence and absence of paleopathological evidence within the skeletal samples.

The research questions and expectations are summarized in Chapter 3 under three areas: public health in American cities; defining health within the MCIG sample; and comparative studies.

This dissertation strives to incorporate the archaeological analysis completed by Patricia Richards (1997) and Richards and Kastell (1993). The stated goal of these studies was to understand the burial program for the Milwaukee County Indigent Grounds within the context of the social structure of the time period. More importantly, the authors looked at the extent to which Milwaukee's poor worked to express individual needs within the established social context. This included examining the surviving material contents buried with each individual. The current study looks at the impact of the social and political context on the health of the individuals interred on the county grounds.

An analysis of the differential impact of degenerative, dietary, infectious, and traumatic processes is only possible when such processes can be separated. With roughly ninety percent of the MCIG burials exhibiting pathological changes, the range of variability in observable skeletal changes would be expected to be more apparent than that typically found in archaeological contexts. Similar studies have shown an increase in the number of degenerative diseases within historical samples with an associated increase in survivability (Higgins *et al.* 2002). As stated, the third goal of this project is to compare the results with other similar samples. The results obtained contribute to ongoing anthropological discussions concerning how diseases are identified from human skeletal remains, the responsibilities of the anthropologists to examine the criteria used in these identifications, and the limitations inherit in the using comparative samples.

Present Study

The primary goal of this study is to assess the relative health of the skeletal sample from the Milwaukee County Institution Grounds (MCIG) cemetery. Chapter two provides a brief history of the city of Milwaukee and its efforts towards improving public health. The events leading up to Milwaukee's first place award by the United States Department of Public Health are reviewed. A brief summary of Milwaukee's institutional care is also included. Chapter three looks more closely at the research questions to be addressed in the present study and the expectations associated with them. Chapter four and Appendix A introduce in more detail the research sample to be used for this project and the methods for data categorization and analysis. Chapter five provides the results of the analysis of select indicators of health on the adult and subadult sample from the MCIG cemetery. Age and sex-specific differences, when found, are included. Chapter six looks at the results of the MCIG analysis in comparison with other similar samples, namely: the Dunning Poorhouse cemetery, Chicago, IL; the Monroe County Poorhouse cemetery, Rochester, NY; and the Voegtly cemetery, Pittsburgh, PA. In addition, a brief comparison of the MCIG skeletal sample and the associated historical documentation is discussed. The final chapter, chapter seven, presents a discussion of the results from both the MCIG analysis and the comparative analysis, and a summary of the research conclusions.

Chapter 2 – Historical Background

"And now wishing that happiness and honor may bless your future years, and that each of you may live to see Milwaukee become what nature intended her for, one of the first commercial cities of the west, I bid you an official farewell."
- Edward O'Neil, City of Milwaukee Mayor, Valedictory Address, April 20, 1864

The Beginnings of a City

Milwaukee began as a center of commerce between French missionaries and the Fox, Mascouten, and Potawatomi tribes (Still 1948). Its location along the fur trade route, established by the travels of French explorers Louis Joliet and Father Jacques Marquette, was originally a seasonal native settlement (Gurda 2006). The later influx of European explorers and merchants established Milwaukee as a trading post for the fur trade, and two rival villages were established by 1837. Combining settlements on the west, east, and south sides of the Milwaukee and Menomonee Rivers, the village concentrated its efforts towards improving water transportation and the development of Milwaukee as a commercial harbor (Still 1948). By the middle of the 19th century, the village saw a rapid expansion in population that produced a complex social network.

Four individuals stimulated Milwaukee's transition from trading post to town: Solomon Juneau, Morgan Martin, Byron Kilbourn, and George Walker (Gurda 2006). Juneau and Martin formed a partnership, buying and selling lots on east side of the Milwaukee River. Kilbourn, arriving after Juneau and Martin, developed a settlement on the west side of the Milwaukee River, while Walker developed the south side of the village, below the Menominee and Milwaukee Rivers. By January 31, 1846, each had expanded his settlement areas and united to form the City of Milwaukee (Gurda 2006).

The growth and development of the city of mirrored national growth trends as immigrants from Europe greatly expanded America's cities. Immigrants from northern and western Europe, particularly the German states, Ireland, and Poland, settled in the Milwaukee area. The flow of immigrants was promoted by they city's expanding industry. By 1850, sixty-four percent of the city's population was foreign-born. Even as recently as 1900, almost one third of the inhabitants of the city were born in Europe (Leavitt 1982)[1].

German immigrants were among the earliest groups to settle in the city. Their early and continued presence created a permanent base of residents in Milwaukee, one that was native to city. The dominance of the German communities also shaped Milwaukee's growth and development (Gurda 2006). Table 1 shows the place of birth for those who died in the city of Milwaukee in 1896. It depicts a community where the majority of those dying within the city are part of the resident population rather than recent immigrants.

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[1] Leavitt (1982) has written a comprehensive book on the history of public health reform in the city of Milwaukee. Its use of the city health department's annual reports as a primary source and its focus on the time period represented by the MCIG cemetery make it the most valuable component in a discussion of Milwaukee's health, where few additional materials are available. As such, it is a dominant source in this dissertation.

Table 1: Place of birth for those who died in Milwaukee in 1896, source *MHD 1897*

Place of Birth	**Number (*n*)**	**Total (%)**
Milwaukee	2,144	2,545 (64.2)
Wisconsin, outside of Milwaukee	158	
Other, of the United States	243	
Canada	20	1,318 (33.8)
Great Britain and Ireland	144	
Germany	915	
Poland	120	
Other European Countries	119	
Unknown	41	41 (1.0)
Total	**3,904**	**3,904 (100.0)**

Milwaukee's growth as an industrial center was encouraged by its strength in manufacturing raw materials from the surrounding areas and its transportation networks. With help from the federal government, the city concentrated its efforts on improving the harbor and building the rail system. Milwaukee's early profits were centered on its commerce in the grain industry, in particular the shipping of wheat. In addition, the manufacturing realm was built upon breweries, slaughterhouses, brickmaking, iron works, and others (Leavitt 1982). While Milwaukee's commerce fueled the city's economy, the city's emphasis on manufacturing created a large labor force, providing ample opportunities for the flood of immigrants calling Milwaukee home. By 1880, approximately forty-five percent of Milwaukee's labor force was industrial workers (Gurda 2006).

Milwaukee and Public Health

As Milwaukee continued to grow, the city could not ignore the problems associated with greater population density and an increasingly complex infrastructure. As Milwaukeeans began to look for alternate ways to relieve the problems associated with this growth, the city was granted permission by the state legislature to create a Board of

Health in 1867 and charged it with overseeing the welfare of the city's residents (Leavitt 1982; Gurda 2006). The Board of Health, and later the Department of Health, focused on three main objectives: infectious disease control; improved sanitation; and food control (Leavitt 1982). The measures undertaken by the Board of Health and the city administrators included taking a more active role in improving the infrastructure of the city, removing its waste, and creating an environment in the public spaces and institutions that limited the spread of disease (Leavitt 1982).

Milwaukee's efforts to improve the condition of the city began immediately after the creation of a board of health in 1867. The following year Milwaukee was faced with a smallpox epidemic. The city's response, led by the board, included vaccination campaigns and school closings to limit the spread of the disease (Leavitt 1982). Epidemics such as this expanded the support for the newly formed board. However, like all major American cities at the time, Milwaukee struggled to find a balance between politics and the need for reform. Issues such as regulation of the city's slaughterhouses or the city's water system were often complicated by economics. The municipal government had to balance the desire to expand Milwaukee's manufacturing interests with the need to regulate the very products that these industries produced (Leavitt 1982).

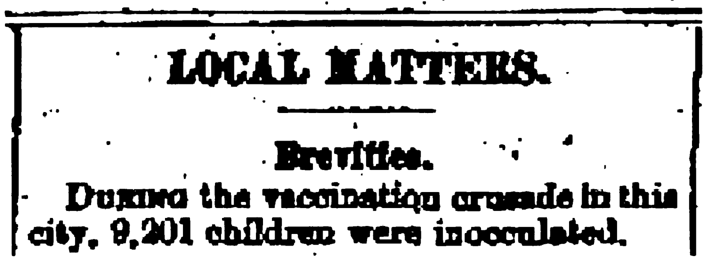
In the later half of the 19th century, the prominent theory concerning the spread of disease was the miasmatic theory. This promoted the idea that unsanitary conditions in cities were responsible for the spread of disease (Leavitt 1982). As a result, early efforts by Milwaukee's Board of Health were dominated by sanitation efforts, such as monitoring the condition of Milwaukee's slaughterhouses, the quality of the city's water and ice, and the disposal of garbage and sewage (Still 1948). In order to address the spread of disease, Milwaukee had to first address the condition of the city's various wards and city streets. Densely populated neighborhoods, open sewers, manure in the streets, and industrial waste created an environment for pathogens to develop and spread quickly (Leavitt 1982). Contaminated food and milk spread contagions across ward boundaries.

When board activity focused on infectious disease, most efforts in the late 19th century centered on isolation of Milwaukee's sick (in both private homes and later city hospitals). Infectious disease, particularly air and water-borne diseases, was a constant threat in most American cities during the late 19th and early 20th centuries. Milwaukee, like other cities, suffered from periodic epidemics of diseases such as smallpox, diphtheria, influenza, cholera, and typhoid fever. The rapid growth and overcrowding in the city increased Milwaukee County's mortality rates from these infectious diseases. Between 1860 and 1930, respiratory and gastrointestinal infections were responsible for a majority of the deaths (Leavitt 1982). Public health concerns arising from these diseases altered the focus of politicians, businesses, schools, and residents. Figure 2 shows an 1881 advertisement for "Downs' Elixir", one of many such ads that dominated newspaper space in the last third of the 19th century. Lack of medical knowledge about the contagions present in the city led to the use of a variety of patent medicines.

Figure 2: "N.H. Downs' Vegetable Balsamic Elixir", source *The Weekly Wisconsin* July 6, 1881

These epidemics, more than anything else, shaped Milwaukee's response towards public health. Each episode required an increased effort to stem the spread of the illness, and the interim often focused on how to prevent and prepare for the similar outbreaks. Figure 3 shows a newspaper announcement for one of many vaccination campaigns for smallpox among Milwaukee's school-age children. The vaccination measures enacted in Milwaukee's schools were often more successful than community measures, and by 1873 the city school board required vaccination against smallpox for all incoming students in the public schools (Leavitt 1982).

Figure 3: "Local Matters – Brevities. During the vaccination crusade in this city, 9,201 children were inoculated.", source *The Weekly Wisconsin* January 18, 1882



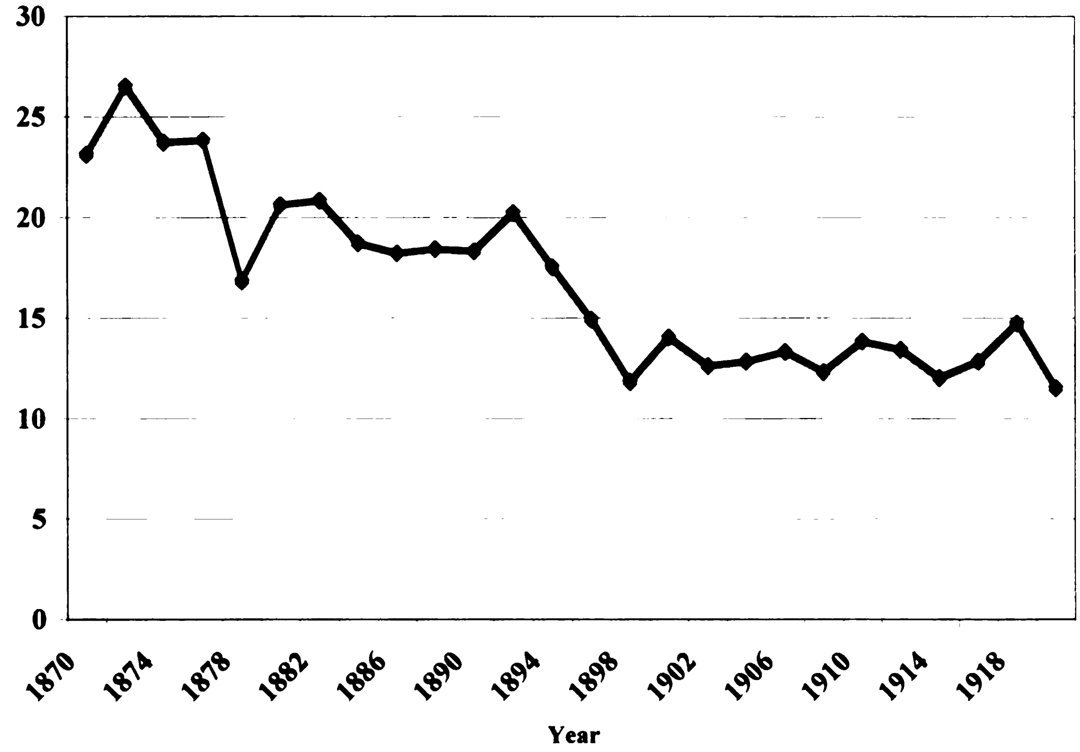
LOCAL MATTERS.

Brevities.

During the vaccination crusade in this city, 9,201 children were inoculated.

The attention to these periodic epidemics often exceeded the attention to more endemic problems, like tuberculosis. Figure 4 shows the death rate for the city of Milwaukee between 1870-1920. The graph shows an overall declining death rate, however, it also shows Milwaukee's struggle with epidemics. The sharp decline seen by 1878 followed a smallpox epidemic in 1876, one of several smallpox epidemics to hit the city prior to 1900. The last peak on the graph shows the impact of the 1918 Influenza outbreak on the city's death rate.

Figure 4: Death Rate per 1,000 for the City of Milwaukee 1870-1920, source *The Healthiest City*, Leavitt 1982



Despite the impact of illnesses on the city, the process of enacting reactive measures was not always smooth. The *11th Annual Report of the Board of Health of Milwaukee 1877* (MHD 1877)[2] includes a short description of the city's efforts to combat smallpox and the frustration with the general populace's lack of understanding as to the importance of preventive measures such as vaccination.

The resistance to vaccination campaigns against smallpox centered on the nature of the vaccine, which produced scarring. Figure 5 shows a drawing of the vesicle created by the small pox vaccine and a description of the normal progression of the disease when

[2] Following the style used in Leavitt 1982, the Annual Reports of the Milwaukee Board of Health and later the Department of Health are referenced as the Milwaukee Health Department Annual Reports and abbreviated MHD with the year of the report.

being inoculated from the 1877 MHD report. This description is one that would be repeated during subsequent small pox epidemics, a disease feared in part because of its ability to disfigure those affected.

Figure 5: Drawing of the vaccination vesicle for small pox, source *MHD Annual Report, 1877*

4th Day Vaccine 9th Day Vesicle

However, changes in medicinal knowledge also changed the focus of the Board of Health. Unlike the earlier theory on the role of a "miasmic" environment, between 1870 and 1930, medical science advanced the ideas of curative medicine and the promotion of germ theory (Leavitt 1982). Despite this, the pre-antibiotic era showed little development in the ability of medicine to cure and treat both acute and chronic illnesses. With the exception of the development of vaccines for illnesses such as diphtheria and smallpox, medicine's contribution to public health was concentrated on explaining how contagions could be passed and what measures could be done to improve urban environments to mitigate the impact of these contagions (Leavitt 1982). By the last decade of the 19th century, the Board of Health shifted its primary focus from the city's sanitation efforts to the examination of the food, water, and milk supply and identifying specific diseases. A newly formed laboratory in 1896 began the city's efforts to systemically examine water and milk samples for contaminates (Leavitt 1982).

By 1912, the threat of severe epidemics of smallpox, cholera, and typhoid had largely passed. City ordinances now mandated the regulation of the city's milk supply, emphasizing the pasteurization of milk to kill harmful bacteria before the milk was distributed to the general public (Leavitt 1982). The control of garbage disposal and other sanitation efforts switched to the Department of Public Works (Leavitt 1982). The Milwaukee Board of Health also added a tuberculosis division to the department to address the need for isolated care for those infected with the disease. Prior to 1912, the city was slow to change its focus on how tuberculosis could be spread and what options were available for treatment. Despite being a leading cause of death in the city, the disease was not considered an infectious disease until 1899. The *MHD* annual report for 1899 reports the first steps towards recognizing tuberculosis as an infectious disease:

> Tuberculosis – a disease so indigenous to the soil of all countries, so constantly with us in its many forms, so destructive that fully one-seventh of all deaths are attributable to its ravages – is at last being accorded due recognition in the community…The mortality of other infectious diseases has markedly diminished because of preventative measures, and it is to be hoped that the classification of tuberculosis among the infectious diseases, will do much to mitigate the severity of this scourge. (p. 24)

One additional area that remained a priority was the infant and child mortality rate within the city. The role of contaminated milk and improper infant care became linked to the high death rate for those under the age of five (Leavitt 1982). The Board of Health, as well as community groups, focused on the systematic education of the residents of the city's wards, particularly those with the newest immigrants to the city. Efforts to reduce the infant mortality rate in the city required the cooperation of both Board of Health officials and the private community-based organizations.

Public Health Reform and the People of Milwaukee

The Board of Health's relationship with the general populace was largely influenced by the connection made with the Milwaukee's various ethnic communities. When conflict occurred between the Board's initiatives and the citizens of the city's various wards, it was most often the result of a lack of understanding about the need for reform. Fear of changing cultural practices, lack of communication between groups speaking different languages, and conflicting information from the city's politicians and the Board of Health all created obstacles to a quick progression of public health reform in the late 19th century.

The 1894-1895 smallpox epidemic provides an example of the dynamic between the Common Council of Milwaukee and the Health Department (Leavitt 1982). City-wide efforts to control the spread of infection included: a massive vaccination campaign; the institutionalization of patients in a Isolation Hospital; a quarantine on infected homes; extensive education programs; and a disinfecting van for the city (Leavitt 1978; MHD 1895). However, the effectiveness of such measures was dependent on the compliance of the people of Milwaukee. Immigrants, particularly German organizations such as the Milwaukee Anti-Vaccination Society, felt that such measures infringed on their rights (Leavitt 1978; MHD 1895). In addition, the Board of Health did not include the city's various ethnic communities in discussions regarding preventive measures. As a result, rioting occurred in the city's wards when residents were forcibly removed to the city's Isolation Hospital (Leavitt 1982). The resulting distrust in the Board of Health actually reduced the power of the Board to act quickly and decisively in the time of an epidemic, the only time that this would happen in the city's history (Leavitt 1982).

Reform movements within the city, particularly those concerned with public health, received much-needed political support with the Socialist movement's control of the city's government beginning in 1910. The movement's proposals emphasized the need to provide for the welfare of its residents (Booth 1985). Milwaukee's political environment had many unique characteristics that enabled such a movement to rise. The city's large German community and its liberal organizations, the large industrial labor workforce, and an ethnically diverse population dominated by immigrants combined to elect Socialist politicians (Booth 1985). In addition, the city was divided into wards centered around the working class and separated by ethnicity. The emphasis on these neighborhoods helped the Socialist movement take root in local politics, and the prominence of disease linked Milwaukee's politics with public health reform (Leavitt 1982).

The election of Socialists to the city's government increased the money available to the city's Health Department between 1910 and 1940 (Booth 1985). In particular, the growth in funds for the Health Department was used to expand the department's efforts towards regulating food and milk production within the city. During this time, the city passed an ordinance requiring tuberculin testing of all milk and initiated projects related to sanitation and health education (Booth 1985). The emphasis on public education and welfare stations paralleled the focus of Milwaukee's various volunteer organizations.

Yet, the contributions of Milwaukee's volunteer organizations were what ultimately shaped the city's progress in public health. These organizations largely focused their attention on helping the poorest segments of the city's population. As health reform provided an opportunity to work outside of the home, many of these organizations were comprised of women from Milwaukee's middle and upper classes (Charaus 2005; Leavitt 1982). The oldest such organization was the Sisters of Charity. Opening Milwaukee's first hospital in 1848, the Sisters of Charity led the way for care of the sick. They, like other organizations, provided early care and shelter for Milwaukee's destitute children, mothers and infants, and those whose indigent status resulted from the city's epidemics, particularly cholera (Charaus 2005; Leavitt 1982).

The beginning of the 20th century saw a combined effort of the volunteer organizations and the Board of Health to reduce infant and child mortality. The Milwaukee's Children's Hospital Association, the Women's Fortnightly Club, and the Milwaukee Maternity Hospital Association, all primarily women's groups, focused their efforts on medical care for the city's poor mothers and children. They opened free hospitals and fresh air pavilions to provide health instruction to those who could not afford private care (Leavitt 1982).

The various organizations, particularly those associated with the medical profession, further shifted Milwaukee's public health focus. Beginning in 1904 with a tuberculosis campaign, the city began to work towards preventative care through broadly based public education programs, using newspapers, distributed pamphlets and posters, used parish and community leaders, and scheduled public lectures (Leavitt 1982).

In regards to addressing Milwaukee's infant mortality, health officials worked to establish child welfare stations in the city's wards. Learning from the political mistakes of the 1893-1894 smallpox epidemic, the Child Welfare Commission was focused on gaining community trust. It was comprised of individuals from the Merchants and Manufacturers Association, the city's hospitals, the Milwaukee Medical Society, and the Visiting Nurse's Association instead of political appointees (Leavitt 1982). While the Department of Health worked with the commission to disseminate information, it left the management of the programs in the hands of the commission. By 1920, the city had opened 14 child welfare clinics. It had established nutrition clinics in the schools, expanded to include prenatal education programs, drastically reduced the city's infant mortality rates, and provided a community-based prevention model that other cities would adopt (Leavitt 1982).

The Development of Institutional Care in Milwaukee

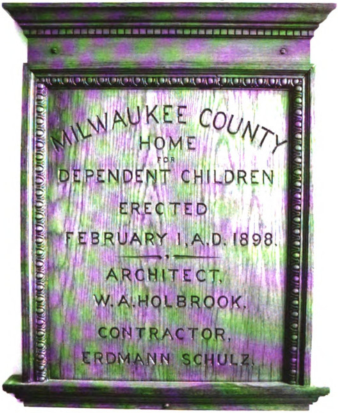
Milwaukee's various organizations also played a role in the early establishment of "outdoor relief" for the city's destitute (Gurda 2006). "Outdoor relief" included handing out food and firewood to the city's destitute (Richards 1997). Early relief efforts were primarily administered by private organizations such as the Catholic Sisters of Charity (Leavitt 1982). As problems with sanitation and disease increased, the number of dependent poor increased, as did the need for greater relief efforts. By 1852, the Milwaukee County Board purchased a 160-acre farm in the town of Wauwatosa and established the county's first institutions for the city's poor (Richards 1997). The city compensated physicians for their time spent attending to those at the almshouse (Leavitt 1982).

By the 1870s, the social problems exceeded the capacity of the small facilities for the destitute that the city had run for several decades. New and expanded facilities were established and organized under medical administrations of Milwaukee County. The county “Poor Farm” in Wauwatosa and the city’s first isolation hospital began to house Milwaukee’s sick poor (Richards 1997; Leavitt 1982).

By 1882, the county established separate institutions in Wauwatosa to house children, the poor, people with a chronic debilitating illness or physical disability, and the mentally disabled (Richards and Kastell 1993). The further separation of various illnesses and age groups continued into the last decade of the 19th century. The Asylum for the Chronically Insane was built in 1889, separating those with chronic disabilities from those with more acute illnesses. In addition, a permanent residence for children, called the Home for Dependent Children, was opened in 1898, providing school instruction and recreation programs for the children residing at the facility (Richards 1997). Figure 6 shows the Home for Dependent Children. Today, the main building is the only surviving building from the original Milwaukee County Institution Grounds Complex. Now the offices of Milwaukee County’s Parks and Recreation Division, figure 7 shows the remaining dedication plaque for the children’s home still located within the entrance hall to the building. These institutions were placed the control of a board of trustees and supervised by a physician (Richards 1997).

Figure 6: "Milwaukee County Home for Dependent Children", portrait located at the Milwaukee County Parks and Recreation Division

Figure 7: "Milwaukee County Home for Dependent Children. Erected February 1, A.D. 1898. Architect W.A. Holbrook. Contractor Erdmann Schulz.", Dedication Plaque for the Milwaukee County Home for Dependent Children



Beginning in the mid-19th century, the burial of the city's poor also became the responsibility of Milwaukee County (Richards 1997). Three cemeteries, located on the Milwaukee County Institutional Grounds, were eventually established for the burial of those who died in Milwaukee's various institutions, the unidentified from the Coroner's Office, and those city residents unable to afford burial costs. The first cemetery, cemetery #1, was used from the early 1870s until 1882 when a new cemetery was established on county grounds. Cemetery #2, the second to be established, was used between 1882 and 1925. The final cemetery, cemetery #3, was used from 1925 until 1974 when the city moved away from indigent burials (Richards 1997). Figure 8 shows a map of the cemeteries established on the grounds relative to modern roads. The cemeteries are labeled with boundary lines, numbers, and in the case of cemetery #1 and #3, a small cross. A register of burial was also established starting with cemetery #2. It records the interments made from 1882-1974. Figure 9 shows the first entry into the Register of Burial.

Figure 8: Map of the cemeteries established on county grounds, source Richards (1997)

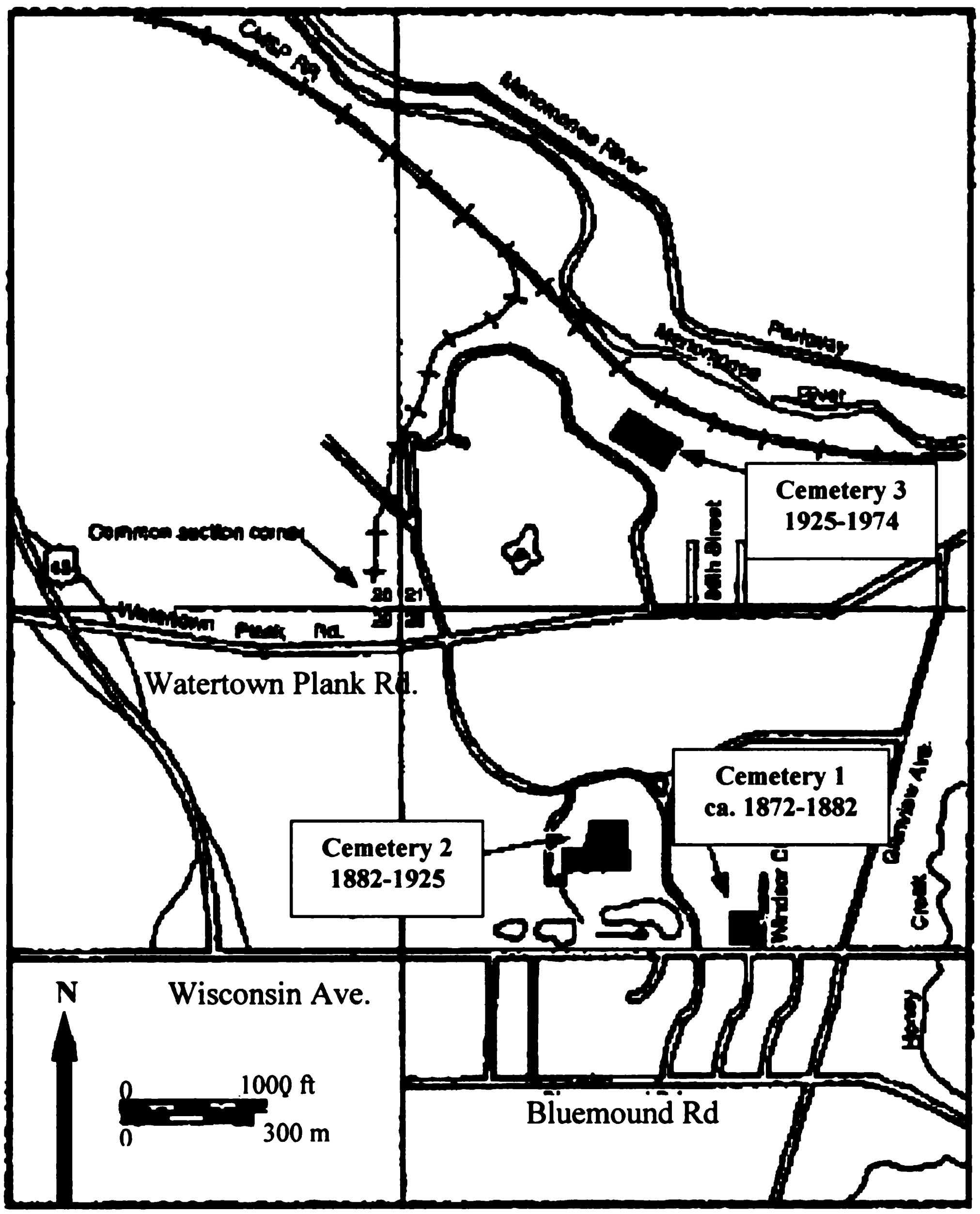
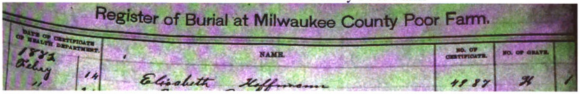


Figure 9: "1882, February 14, Elizabeth Hoffmann, 48 87, H1", First entry in the Register of Burial at Milwaukee County Poor Farm


Register of Burial at Milwaukee County Poor Farm.

Date of Certificate of Health Department.		Name.	No. of Certificate.	No. of Grave.	
1882 Febry	14	Elizabeth Hoffmann	48 87	H	1

Conclusion

In 1870, the city death rate was 23.3% with endemic and epidemic disease accounting for the majority of deaths (Leavitt 1982). However, the reform movements and campaigns eventually saw the reduction of mortality rates associated with infectious diseases, and by 1920 the city boasted a death rate of 11.6% (Leavitt 1982). In 1930, Milwaukee was awarded first place in its population class in the first annual U.S. Chamber of Commerce and American Public Health Association Health Conservation Contest for its public health accomplishments. The contest would continue through 1943 with Milwaukee winning honors as the "Healthiest City" in 10 of the subsequent 13 annual contests (Leavitt 1982). The skeletal sample used in this dissertation comes from the Milwaukee County Institutional Grounds Cemetery #2. It spans the years between 1882-1925 and represents the time period after the formation of Milwaukee's permanent Board of Health and before Milwaukee received its first award as "America's Healthiest".

Chapter 3 - Research Questions and Expectations

Introduction to Research Goals

As introduced in Chapter 1, the goals of the current study seek to address the contribution of a biological analysis of skeletal remains from the Milwaukee County Institution Grounds to available archaeological and historical evidence. The research questions posed look at those areas of analysis that would contribute the most to an understanding of the life and death of those interred on county grounds. The research goals for this dissertation are as follows:

1) The archaeological analysis focused on establishing the context in which the MCIG remains were situated, namely as part of the larger community surrounding the city of Milwaukee. This study seeks to expand upon the archaeological work by focusing on the sociopolitical context at the time the cemetery was in operation and using available historical records to identify the public health initiatives that may have impacted the health of those interred on county grounds.

2) The study seeks to use the skeletal analysis from the MCIG cemetery to address the health of residents of a city once deemed "America's Healthiest" (Leavitt 1982). The goal is to use several skeletal indicators of growth and development and pathology to correlate the city's efforts towards public health initiatives and the impact such efforts may have had on both adult and subadult individuals from the MCIG cemetery.

3) The analysis of health from the MCIG remains is relative to what is observed in other samples. The third goal is to compare the sample used from the MCIG cemetery to similar skeletal samples. The study will look at both the observed health and the differences in how health is assessed in each sample, to assess the significance of the presence and absence of paleopathological evidence within the skeletal samples.

The research questions and expectations are summarized in the following section under three areas: public health in American cities; defining health within the MCIG sample; and comparative studies.

This dissertation strives to incorporate the archaeological analysis completed by Patricia Richards (1997) and Richards and Kastell (1993). The stated goal of these studies was to understand the burial program for the Milwaukee County Institution Grounds within the context of the social environment of the time period. More importantly, they evaluated the extent to which Milwaukee's poor worked to express individual needs, even in burial, within the Milwaukee County Institutional Complex. The current study looks at how the social context of both Milwaukee's institutions and the city proper may have affected the health the individuals interred on the county grounds.

Assessing the relative health of a skeletal sample includes examining the impact of degenerative, dietary, infectious, and traumatic processes. With roughly ninety-percent of the MCIG burials exhibiting pathological conditions, the range of variability in observable skeletal changes is expected to be more apparent than that typically found in archaeological contexts. Similar studies have shown an increase in the number of degenerative diseases within historical samples with an associated increase in survivability (Higgins *et al.* 2002). As stated, the third goal of this project will be the ability to compare the results with other similar samples. The results obtained contribute to ongoing anthropological discussions concerning how disease is identified in human skeletal remains. It also looks at what criteria are used to identify disease and what limitations are present when using bioarchaeological evidence to examine the health of a sample.

Research Questions and Expectations

Public Health in American Cities

Identifying Sociocultural Initiatives related to Public Health

The Milwaukee County Institutional Grounds is located on county land in the city of Wauwatosa, which borders the western edge of the city of Milwaukee (Richards 1997). While still a part of the urban setting of the city of Milwaukee, the grounds' location removed those committed to its facilities from the city proper. Personal effects associated with a portion of the burials as well as the submission of annual reports from Milwaukee's various institutions provide evidence for the inclusion of the MCIG complex as part of the context of the larger community (Richards 1997).

This dissertation considers the sociocultural initiatives aimed at addressing public health that may have affected those interred on county grounds. During the late 19th and early 20th century, the city of Milwaukee took action to improve the city's welfare. These actions addressed several areas of concern: the institutionalization of Milwaukee's indigent, infirm, and mentally disabled; the promotion of mass vaccinations; the creation of public health policies aimed at sanitation efforts and control of pathogens; and the promotion of improved working conditions. With the formation of the city of Milwaukee Department of Health in 1867, most sociocultural initiatives during the subsequent 50 years would focus on sanitation, food control, and infectious diseases (Leavitt 1982).

The "Epidemiological Transition" and its Relation to Public Health Initiatives

While highly stressed, the population did develop adaptive biological strategies. This is evidenced by the presence of both healed and prolonged infection. The ability of at least a portion of the sample to sustain a defense against generally acute infectious pathogens, such as tuberculosis, shows the development of biological resistance to specific disease processes. In addition, the prevalence of degenerative processes portray the impact of endemic rather than epidemic disease processes. Evidence for an epidemiological transition has been shown with other historical samples (Barrett *et al.* 1998; Fenner 1970; Gage 2005). Given Milwaukee's historical emphasis on public health initiatives, especially during the timeframe represented, the MCIG sample would be expected to reflect such a transition with declines in morbidity rates due to infectious processes and associated increases in morbidity from degenerative or chronic disease processes.

Defining Health within the MCIG Sample

Identifiable Indicators of Health

Studies such as those by Lanphear (1988), Higgins and Sirianni (1995), Grauer and McNamara (1995), and *Human Remains from Voegtly Cemetery* (2003), focused on selective criteria for highlighting the health of a population in comparative studies. These variables include: evidence for porotic hyperostosis (including cribra orbitalia); dental enamel hypoplasias; periosteal lesions; and measurements related to stature and growth. As mentioned above, the comparison of degenerative and infectious processes based on demographic variables such as age and sex is also included in this dissertation. The MCIG sample presents evidence for each of these indicators of health.

The expectation is that within the MCIG sample there will be higher levels of stress from activity-based stressors and pathogenic (infectious disease) stressors and less dietary-related stressors. Measures of degenerative joint disease, specific, and non-specific infections will be used to address the presence of activity-based and pathogenic stressors. Dietary-related stressors, as well as growth and development disruptions will be addressed by looking at the presence of linear enamel hypoplasias, porotic hyperostosis, and cribra orbitalia.

This expectation is based on pre-dissertation studies highlighting the high frequency of degenerative process among the adults, and the observed skeletal evidence for specific diseases among both adult and subadults in the sample. In addition, while poorhouse studies (Higgins and Sirianni 1995; Grauer and McNamara 1995) highlight the unsanitary conditions and poor diet of early American almshouses, the MCIG sample also consists of a large number of individuals from the city instead of simply from the institutions built to house the indigent. Early reports (prior to 1870) that do address the conditions at Milwaukee's institutions tend to highlight overcrowding and the spread of disease instead of diet (Richards 1997).

Evidence for Degenerative and Infectious Processes

The separation of specific pathologies also facilitates discussions related to comparative studies. Rather than simply addressing what information can be gleaned about the overall health of the sample, the examination of specific pathogens looks at what was affecting health at both an individual and population level. The expectations for the MCIG sample, based on comparing data from historical records, would be that the proportion of individuals affected by degenerative processes would exceed those affected by infectious processes. While these degenerative processes cannot be used to address the mortality rate within the sample, they would contribute to the rate of morbidity and the quality of life (Waldron 2007). Given the prevalence of specific pathogens within the city of Milwaukee, the MCIG sample would also be expected to show skeletal evidence for infectious pathogens such as tuberculosis and syphilis.

Differences in Health based on Age and Sex

Grauer *et al.* (1998) observed that, in the city of Chicago, the Dunning Poorhouse sample showed differentiation between adult males and females with regards to both the age structure and patterns of paleopathology. The MCIG sample also reflects a disparity in its demographic composition. The male to female ratio is approximately 7:1, while the adult to subadult ratio is estimated at 2:1 (Sullivan *et al.* 2008). As such, the number and variability of pathological observations are expected to be greater for adult males in the sample than that that of either females or subadults.

This expectation considers that fact that those interred on county grounds came from both Milwaukee's institutions and the city itself. Milwaukee, like other American cities of the time, experienced a large influx of immigrant workers as it expanded its commercial and industrial interests. A larger complex of support for women within the city's communities and the greater portion of males, particularly immigrant males, within the workforce would be expected to affect the types of pathologies seen with each subset. Degenerative processes are more likely to be seen with the adult population, particularly those classified as old adults, which may be related to increased survivability. Infectious processes are expected to be represented throughout the sample. Exposure to disease threats is expected to be similar across all age and sex groups because of historical documentation of the citywide impact of such threats and the broad-based city initiatives aimed at combating the threat of disease. However, among subsets of the sample, specifically subadults, the expectation is that there will be less evidence for these processes due to acute infections rather than chronic. Adults affected by multiple stressors would be expected to show higher levels of infectious processes. With an increased focus on women's health, particularly maternity and infant care in the early 20th century, differences between the males, females, and subadults are expected to be seen in indicators of health that examine nutritional and growth disruptions, in addition to evidence of infectious disease (Leavitt 1982).

Temporal Trends within the Sample

The *Reports of Investigation No. 333* (Richards and Kastell 1993) detail efforts during the original excavation to date sections of the cemetery based on artifactual evidence. The excavated sections of the cemetery were divided into Areas A-N and were arbitrary depending on construction schedules (Richards and Kastell 1993). Each area was assigned separate burial lot numbers. The archaeological report also details efforts to define the original areas of the cemetery based on the spatial organization of the graves and features such as post molds and old roads. When estimates of the original areas of the cemetery could be made, artifactual evidence such as recovered burial tags helped narrow the timeline associated with small sections of the excavated cemetery. However, overall the excavated sections of the MCIG cemetery present little recovered evidence that would associate the excavated burials with the original burial records for the cemetery. As such, the sample is expected to show limited evidence for temporal trends in paleopathology. When such evidence is available, the expectation is that the MCIG sample would show increased evidence for disease processes, both degenerative and infectious, in the later periods of the cemetery's use. This expectation reflects the assumption that increased survivability of acute stressors would be associated with increased citywide public health initiatives (Leavitt 1982).

Comparative Studies

Comparisons with Historical Records

The most frequently cited causes of death listed in the historical records for the cemetery are gastrointestinal and respiratory diseases (*Register of Burial 1882-1925;* Leavitt 1982). In general, the pathologies that can be discerned from skeletal remains are limited to those that have the ability to affect the bones and are generally chronic rather than acute in nature (Ortner 2003). While other types of pathologies such as those related to trauma or degenerative processes may also be visible in the skeletal record, they may not be listed in historical records. As stated earlier, the MCIG sample is expected to exhibit a high level of degenerative pathological conditions. In addition, the sample is expected to represent trauma and infectious disease, while under-representing acute disease processes.

Established Prevalence Rates

Ortner (2003) points out that, based on published prevalence rates, only a small percentage of individuals who have an infectious disease will exhibit skeletal evidence of the disease. Depending on the disease, the number of individuals who might show signs of infection may vary. In addition, the severity, extent of infection, and evidence for healing varies depending on whether the disease was active at the time of death. If the sample is more susceptible to acute processes, then the sample is expected to show a lower prevalence of specific infectious diseases. Given the frequency of infectious disease in the *Register of Burial* for the MCIG sample, the sample is expected to show evidence for both nonspecific infection and specific infectious diseases, such as tuberculosis. However, the frequency of observable skeletal changes associated with these processes is expected to be lower than the frequency of infectious diseases in the burial registry. Variability in preservation within the MCIG sample is expected to affect the prevalence of disease within the different age and sex cohorts (Waldron 2007).

Comparisons with Similar Samples

Similar studies of historical urban skeletal samples show high mortality (when looking at associated historical records) and morbidity rates prior to the time period represented by the MCIG sample. Collectively, these studies encompass a timeframe beginning in 1826 and ending by 1870 at the beginning of more aggressive public health policies within the nation's urban areas. As such, the MCIG sample is expected to reflect a comparably lower rate of identifiable pathogens and increased survivability over time. In addition, the MCIG sample includes individuals from both Milwaukee's institutions and those from the larger community. The demographics associated with both the skeletal remains and associated burial records would reflect differences between those cemeteries associated with an institutional population only. A brief summary of the reported results from the comparative skeletal samples used in the current study follows.

Monroe County Poorhouse / Highland Park Cemetery

The Highland Park Cemetery is associated with the Monroe County Poorhouse and other nearby institutions. Its population represents those who were residents of these institutions. The skeletal sample shows a highly stressed population, particularly with regards to exposure to infectious disease. For example, Lanphear (1988) reports a roughly 20% prevalence rate for tubercular lesions. In addition, 56% of the adult and subadult burials showed evidence for a periosteal reaction, a non-specific indicator of health (Lanphear 1988).

Dunning Poorhouse Cemetery

Like the Highland Park skeletal sample, the Dunning Poorhouse Cemetery is associated with the Cook County poor farm and its institutions. The high subadult mortality rate was found to be significantly different than that of the city of Chicago (Grauer and McNamara 1995). The sample also showed high levels of stressors, but found that these stressors included both active and healed processes (Grauer *et al.* 1998). Grauer *et al.* (1998) also found that these stressors differentially affected males and females residents.

Voegtly Cemetery

The Voegtly Cemetery, while encompassing the same time period as the Highland Park and Dunning cemeteries, is associated with the Voegtly Church community. As such, the sample draws from a congregational community, while the others are comprised of indigent burials. The cemetery reflects a community struggling to adapt an urban lifestyle (*Human Remains from Voegtly Cemetery* 2003). Evidence for high infant mortality, disease, and poor nutrition are present in the sample. Looking specifically at the presence of disease, the Voegtly Cemetery shows a similar prevalence for diseases such as tuberculosis as epidemics affected everyone within the larger community regardless of social class (*Human Remains from Voegtly Cemetery* 2003).

Summary

The research questions and expectations outlined in this chapter require the use of multiple lines of evidence. The skeletal analysis for the MCIG remains, an analysis of associated historical evidence, and the comparisons of the Milwaukee sample with other samples all serves to shed light on the relative health of the sample. As stated in the introduction, the goal of the current study is to use the skeletal analysis from the Milwaukee County Institution Grounds Cemetery to assess the life and death of those interred on county grounds. It provides physical evidence of the impact of stressors present within the city of Milwaukee. It also provides the opportunity to use bioarchaeological data to contextualize Milwaukee's place within America's cities during the late 19th and early 20th centuries. The next chapter will detail how the questions posed by this chapter will be addressed.

Chapter 4 – Materials and Methods

This chapter outlines the primary research sample used for this study and the data collected from the sample. A description of the methods used in the data collection, as well as a description of the methods selected to address the research questions outlined in Chapter 3 are also included. As this study looks at the MCIG sample in comparison to other skeletal samples, the chapter concludes with a summary of all the samples used. All data collected during the principal investigation, conducted prior to the present study, was collected using *Standards for Data Collection from Human Skeletal Remains* (1994). Appendix A includes the scoring system used to categorize the original MCIG data.

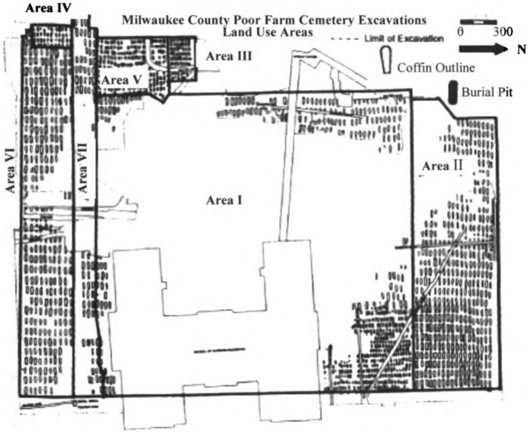
Milwaukee County Institution Grounds Cemetery

Introduction

Between 1991 and 1992, a portion of the Milwaukee County Institution Grounds (MCIG) cemetery #2 was excavated by the Great Lakes Archaeological Research Center, Inc. (Richards and Kastell 1993; Richards 1997). The cemetery, the second to be established on County Grounds, was in use from August 1882 until July 1925 (Richards and Kastell 1993; Richards 1997). Those interred in the burial ground included residents from Milwaukee's various institutions, members of society unable to afford burial fees, as well as, unidentified and unknown remains from the coroner's office. The excavated sections were divided into arbitrary Areas A-N, which yielded a total of 1,649 individuals, 985 adult remains, 588 classified as subadult, and 76 fragmented remains (Sullivan *et al.* 2008). The excavated areas represent the original areas of the cemetery, numbered I-VII, added individually between 1882-1925 as the burial grounds expanded

(Figure 10). The excavated remains represent the entire time during which the cemetery was in operation, although only 1,649 individuals were recovered from the 5,288 listed in the burial record for cemetery #2 (*Register of Burial 1882-1925*).

Figure 10: "Milwaukee County Poor Farm Cemetery Excavations Land Use Areas" (Richards 1997)



Data collection

The publication of *Standards for Data Collection from Human Skeletal Remains* (1994) provided for standardization of data collection within archaeological contexts. Published in 1994, the volume includes methods for the biological analysis of human remains that have been widely used by researchers for most contemporary studies, including those that pre-date its publication. Between 1994 and 2007, researchers at Marquette University collected data as outlined by *Standards* (1994) from the excavated remains of the MCIG cemetery #2. The data includes: an inventory of the bones present for each individual and the completeness of each of those elements; observations of dental pathologies; estimations of age and sex for adults and estimations of age for subadults; cranial and post-cranial measurements; observations of non-metric traits; and observations of skeletal pathology. Descriptive notes and photographs were also collected, particularly in regards to any pathological or surgical observations.

For the purposes of this dissertation, a sub-sample of both the adult and subadult remains is used. The sub-sample represents all excavated sections of the cemetery, and is representative of the entire timeframe during which the cemetery was in operation. It is taken from the total number of remains included in the overall skeletal analysis. Individuals excluded from the principal analysis either were too poorly preserved to collect data or were classified as commingled and individual remains could not be identified. As such, the principal study of the MCIG remains included 874 adults and 544 subadults. Table 2 shows a summary of the number of adults and subadults included in the principal investigation and the excavated areas from which they were recovered.

Table 2: Number of burials and the represented excavation areas

Excavated Area (Assigned Lot #s)	Number of Adults (*n*)	Frequency (%)	Number of Subadults (*n*)	Frequency (%)
B (1000-1053)	48	5.5	0	0.0
C (2000-2160)	142	16.2	1	0.2
D (3022, 3026-3075)	46	5.3	0	0.0
H (5000-5259)	204	23.3	1	0.2
J (6000-6295)	28	3.2	252	46.3
K (7000-7264)	190	21.7	40	7.4
L (8001-8202)	72	8.2	3	1.0
N (9001-9475)	144	16.5	247	45.4
Total Sample	874	100.0	544	100.0

The adult sample selected for this project includes the 491 remains, out of the 874 adult remains available, which have both age and sex estimations. The remains represent excavated areas B, C, D, H, J, K, L, and N. These areas are all of the original areas of excavation that yielded adult remains. In addition, a random sample, comprised of 10% of the remaining individuals in each area, added 42 adult remains. The study sample consists of a total of 531 adults, which represent 60.8% of the 874 adult remains analyzed. Table 3 shows a summary of the adult sample used for this dissertation and the excavated areas from which they were recovered.

Table 3: Adult research sample and represented excavation areas

Excavated Area (Assigned Lot #s)	Number (*n*)	Frequency (%)
B (1000-1053)	25	4.7
C (2000-2160)	72	13.6
D (3022, 3026-3075)	43	8.1
H (5000-5259)	151	28.4
J (6000-6295)	12	2.3
K (7000-7264)	47	8.9
L (8001-8202)	67	12.6
N (9001-9475)	114	21.5
Total Sample	531	100.0

The subadult sample includes the 373 subadult remains with associated age estimations. The remains represent excavated areas C, H, J, K, L, and N. These areas are all of the original areas of excavation that yielded subadult remains. As shown in Table 4, most subadults were recovered in areas J, K, and N, with area J being comprised almost entirely of subadult burials. In contrast, areas C, H, and L consisted primarily of adults. In addition, a random sample, comprised of 10% of the remaining individuals in each area, added 19 subadult remains. The overall sample consists of a total of 392 subadults, which represent 72.1% of the 544 subadult remains analyzed.

Table 4: Subadult research sample and represented excavation areas

Excavated Area (Assigned Lot #s)	Number (*n*)	Frequency (%)
C (2000-2160)	1	0.3
H (5000-5259)	1	0.3
J (6000-6295)	198	50.5
K (7000-7264)	24	6.1
L (8001-8202)	3	1.0
N (9001-9475)	165	42.1
Total Sample	392	100.0

The excavated sections of the MCIG cemetery represent about one-third of the original interments in the cemetery and as such represent a sample of the original cemetery. The adult and subadult research samples selected for this dissertation reflect the entirety of these excavated sections. Given the estimated timeframes associated with the cemetery, the sample provides age and sex-specific data throughout the length of time the MCIG cemetery #2 was in operation. Sampling each excavated area allows for the best representation of both the overall skeletal sample and the individuals interred on county grounds. The ability to examine paleopathology in relation to demographic variables such as age and sex establishes a better context for the conclusions that could be made about the cemetery as a whole.

Age and Sex Determinations

Both age and sex estimations consider multiple factors. The number of indicators used depended on the completeness of the burial. Assessments of sex focus specifically at the morphology of the skull and pelvis as outlined by *Standards* (1994). The methods include observations of cranial features such as the mastoid process, nuchal crest, supraorbital margin, supraorbital ridge (glabella), and mental eminence. Observations of pelvic features focus primarily on those included in the Phenice method (Phenice 1969): ventral arc, subpubic concavity, and the ischiopubic ramus ridge. When available, the subpubic angle was also included in observations of the pubic region. In addition, features such as the greater sciatic notch and the preauricular sulcus were considered.

Due to varying levels of preservation, 87.0% of the adult sex estimations include cranial features, 47.6% include observations of the pubic region, and 14.1% exhibit all of the cranial and pelvic features used in the sexing methods (Milligan *et al.* 2008). The excavated remains are separated into five categories: male; probable male; female; probable female; and ambiguous. Classifications of 'probable male' or 'probable female' were given when only limited information related to sex was observable on a particular skeleton. The term 'ambiguous' was used for those individuals that exhibited features scored as both male and female

Age estimations for the adult burials were established using a multifactorial approach. Consideration was given to all suggested age ranges based on the scoring of several cranial and pelvic features. The primary methods used follow those outlined in *Standards* (1994), including: cranial suture closure (composite method); pubic symphysis (Todd 1921a, 1921b; Brooks and Suchey 1990; Suchey and Katz 1986); and the auricular surface (Lovejoy *et al.* 1985; Meindl and Lovejoy 1989:165). Secondary age indicators such as arthritic or degenerative changes and antemortem tooth loss were also considered.

As with sex, varying levels of preservation produced some limitations on the methods utilized with each individual burial. As such, 37.3% of the adult age estimations include observations of the pubic symphysis, 73.0% include observations from the auricular surface, and 14.0% include observations of cranial suture closure. Overall, only 5.0% of the sample exhibits all cranial and pelvic features used in the aging methods (Milligan *et al.* 2008). The combination of these age ranges and secondary observations of age allow the remains to be placed in one of three categories: young adult (20-34 years); middle-aged adult (35-50 years); and old adult (50+ years) (Sullivan *et al.* 2008). The age categories are consistent with those recommended by *Standards* (1994).

Observations of dental formation and tooth eruption patterns (Ubelaker 1989a; Moorees *et al.* 1963a, 1963b), long-bone growth (Fazekas and Kosa 1978), and epiphyseal closure (Krogman and Iscan 1986) provide age estimations for 373 subadults. The subadult remains are divided among three categories: infant (less than 1 year); child (1-4.9 years); and juvenile (5-19.9 years). Of these, 88.3% of the subadults are less than 1 year of age at death. As all of the age estimations for the subadults are less than 20 years of age, no observations of sex were considered given the lack of accuracy found in estimations of sex with immature remains (*Standards* 1994).

The skeletal age categories took into consideration the available historical information and the categories used in other skeletal samples. For example, the subadult age categories coincide with how reported causes of death are listed in the annual reports by Milwaukee's health department. For the burial registry, cause of death information is listed for the years 1904-1905, 1908-1913, and 1916-1920. Most subadult deaths occur in the infant and 1-6 year range, specifically 1-5 months and 1-2 years of age. The most frequent cause of death varies with different age cohorts. Malnutrition, infectious diseases, and diseases of the respiratory system are the most frequent for those less than 1 year of age. Diseases of the respiratory system alone account for 63.8% of the deaths for those between 1 and 6 years of age. Infectious disease, diseases of the digestive system, and congenital malformation account for the majority of the deaths for those between the ages of 6 and 18 years of age (Dougherty *et al.* 2005).

The use of subadult age categories in other skeletal samples typically groups those under 1 year of age and uses 1 to 5-year categories thereafter. When narrow age ranges can be established, the age increments are generally one to two years. When less information is available, the increments are generally five years or greater.

The reported demographics of the sample are based on the skeletal analysis and the associated burial records. As a note, life tables were not constructed during the demographic analysis of the MCIG sample. A primary assumption of their use in reconstructing paleodemographic structure is that the population is both stable and relatively stationary (Ortner 2003). The MCIG sample represents several different populations, none of which could be considered stable. Those included in the burial grounds came from Milwaukee's various institutions, the unidentified dead from the community at large, and those residing in poverty within the city of Milwaukee. Each of these groups included long-standing residents of the city of Milwaukee, as well as recent immigrants to both the region and country. The MCIG collection could also not be considered a true sample of the populations included, as it is not a random sample of those who were once living (Waldron 2007).

Historical Archives

The historical documentation associated with the sample includes census and death records for both the city of Milwaukee and its various institutions, annual reports from the city's institutions, burial records for the county grounds, coroner's reports from Milwaukee's various hospitals, accounts from Milwaukee's various newspapers, and reports on public interest projects from resident organizations (Sullivan *et al.* 2008). In particular, the *Register of Burials at the Milwaukee County Poor Farm 1882-1925* is used to help establish expected demographics, examine trends in causes of death, and to highlight the different populations from which individuals buried on county grounds were derived. The *City of Milwaukee Annual Reports* (1861-1874) and later the *Milwaukee Board of Health Annual Reports* (1875-1932) are used to examine the city's efforts towards public health reform and the impact that such measures had on morbidity and mortality rates within the city of Milwaukee.

The first section for the research questions outlined in Chapter 3 looks at public health in American cities. Particularly, the questions address what evidence is available for public health reform and what historical evidence for epidemiological shifts can be identified. The historical sources mentioned above are used to address the research questions related to public health in American cities. They are also used to address research expectations based on the comparison of the skeletal sample with historical records.

Paleopathology and Indicators of Health

Previous to this study, researchers recorded paleopathological observations for all individuals who exhibited signs of skeletal stress. Ortner (2003) points out that, in a typical archaeological sample, 15% of the individuals will show evidence of significant disease (ranging from trauma and activity-induced pathologies to infection). In the case of the MCIG sample, more than 90% of the total sample exhibits some form of pathology (Sullivan *et al.* 2008). The remaining individuals who were not recorded for pathology either show no evidence of pathology, were excluded due to commingling, or lack the preservation needed to make any pathological assessments. For the adult sample used in this dissertation, 500 individuals show some evidence of skeletal pathology while 31 individuals either exhibit no pathology or lack the preservation needed to make such assessments. For the subadult sample used in this study, 18 subadult remains show evidence of skeletal pathology, 360 exhibit no evidence of pathology, and 14 lack the preservation needed to make any pathological assessments.

The pathological conditions and disruptions to growth observed were recorded using the data collection protocol outlined in *Standards* (1994). This study focuses specifically on the following pathological conditions and developmental disruptions, and their role as indicators of health within the MCIG sample: linear enamel hypoplasias, porotic hyperostosis, cribra orbitalia, and periostitis. In addition, femur lengths for both the adults and subadults are included in the paleopathological assessment. Individuals who exhibit signs of infection, both generalized and specific, as well as degenerative processes are also examined.

These indicators are used to address the second area of research questions, namely how skeletal health is assessed. Research expectations for the presence of these indicators contribute to an analysis of observable differences in health based on biological variables such as age and sex. They also provide measures of comparison between other skeletal samples. The following sections discuss each indicator in greater detail.

Stress and Disruptions to Growth

Linear Enamel Hypoplasias

Enamel hypoplasias are defined as the interruption of enamel development, most often the result of a physiological disturbance, where the thickness of the enamel being deposited is altered (Goodman and Rose 1990; Larsen 1997). These disruptions to enamel development in teeth are often the result of systemic stressors during early development (*Standards* 1994). The resulting defects can be attributed to a number of factors, including: malnutrition, infectious disease, genetic anomalies, and trauma

(Goodman and Rose 1991). The defects observed in tooth enamel are often a strong indicator of the presence of systemic stressors as dental tissue is not easily affected (White 2000).

Linear enamel hypoplasias (LEH) are included as an indictor of health for both the adults and subadults. However, the information provided by such observations differs between the two groups. The enamel defects found within the subadult sample, particularly within the less than 1 year and 1-4.9 cohorts, are used to assess systemic disruptions to growth that may have had an impact on the health of the individual around the time of death. In contrast, the enamel defects found in adults are used to examine the presence and impact of systemic stressors in early childhood. While the correlation of childhood stress and adult health can be complicated by other factors, the presence of such stress may indicate a reduced resistance to systemic stressors, particularly infectious diseases. A study by Boldsen (2007) found that younger adults with linear enamel hypoplasias exhibited a higher mortality rate than those without it. The presence of these defects in either the adults or subadults is considered a nonspecific indicator of stress.

Observations of enamel hypoplasias in both the adult and subadult sample were collected during the principal investigation of the MCIG sample, according to *Standards* (1994). These observations included both linear enamel defects and enamel opacities that were macroscopically observable or seen without the aid of a microscope. In addition, a measure from the midpoint of the labial/buccal cemento-enamel junction (CEJ) to the most occlusal portion of the hypoplasias was recorded. Enamel hypoplasias, when observed, consisted of linear horizontal or vertical grooves resulting from changes in the thickness of the tooth enamel (*Standards* 1994). The deficiencies in enamel could also be expressed in arrays or groupings of pits in the enamel. In addition, enamel opacities or transverse bands reflecting changes in enamel color were also recorded with hypoplasias, as they are commonly the result of systemic stress (*Standards* 1994).

For this study, observations of hypoplasias on the mandibular and maxillary incisors and canines are examined. Individuals with defects across more than one deciduous or permanent tooth are included in the study as systemic stress normally produces defects across multiple teeth (*Standards* 1994). In addition, the location and number of hypoplasias seen on individual teeth is noted. Individuals with less than two observable anterior teeth or excessive crown wear were excluded from consideration.

The results are presented by individual counts. Lukacs (1992) includes a discussion of the merits of using individual reporting methods versus tooth count methods when addressing dental paleopathology. The first method reports the number of individuals affected by the disorder while the second reports the prevalence of the disorder by tooth type and class (Lukacs 1992). The decision to report by individual count was based on the focus of the study, namely the relative health of the individuals interred in the MCIG cemetery, and consistency in the level of analysis as the other indicators of health are reported on the individual level. The size of the MCIG sample, even when divided by age and sex cohorts, allows for reliable statistical analysis at the individual level.

Porotic Hyperostosis

Porotic hyperostosis refers to the expansion of the marrow cavity, most often associated with the cranial vault (Larsen 1997; Ortner 2003). As the diploë expands, the outer table is gradually resorbed (Walker *et al.* 2009). Evidence for porotic hyperostosis is frequently observed in skeletal assemblages and has been routinely linked to nutritional deficiencies in human populations. Specifically, it is often considered indicative of iron-deficiency anemia.

While an anemic disorder may cause porotic hyperostosis to occur, the presence of the pathology does not necessarily indicate a deficiency in iron. Ubelaker (1992) points out that porotic hyperostosis is the body's response to an increased need for red-blood cell production, which is accomplished by an expansion of the medullary-cavities in the affected skeletal elements. Ubelaker looks specifically at the effects of increased sedentism, population density, and problems with sanitation on increases in infection loads within populations. The study finds that, while dietary factors may contribute to the prevalence of porotic hyperostosis, diseases processes are a major factor in the presence of the pathology. Similarly, Holland and O'Brien (1997) examine the role of parasitic agents in contributing to the presence of porotic hyperostosis. They conclude that both diet and various pathogens, parasitic as well as bacterial, may lead to the expression of the pathology. Walker *et al.* (2009) suggest that, when an anemic disorder is involved, anemias that cause the premature death of red blood cells and increased red blood cell production may be more likely to be the cause. They suggest that deficiencies of vitamin B_{12} may be passed from mother to offspring, coinciding also with a decrease in immune resistance to infection.

This pathology is included in the present study as an indicator of nonspecific stress for both adults and subadults because of its relevance to environmental conditions seen with increases in population density. However, the status of the lesions in adults and the timing of their formation highlight some age-specific differences. More often than not, individuals exhibiting active, unhealed lesions are children and adolescents (Larsen 1997; Walker *et al.* 2009). The fact that most hyperostosis observed in adults is remodeled and/or healed leads to the conclusion that the formation of this pathology is related to stressors present during childhood. As such, the measures of porotic hyperostosis seen in adults and subadults provide different information about the health of the individual in question. Subadults, particularly those in the younger cohorts, displaying evidence for these lesions demonstrate the presence of systemic stress around the time death. In contrast, porotic hyperostosis in adults, like the presence of enamel hypoplasias, may be more indicative of childhood stress.

Observations of porotic hyperostosis in parietal, frontal, and occipital bones were recorded during the principal investigation of the MCIG sample following the scoring system found in *Standards* (1994). The observations collected involve pitting or porosity of the outer table. The location of the pathology and severity are noted. When present, the status of the pathology is categorized as follows: active at the time of death; healed; or a mixed response. Individuals with at least one observable parietal present are included in this study. In addition, the presence of the occipital or frontal bone was necessary for inclusion in the sample set where frequency of porotic hyperostosis for that bone was considered. Individuals were excluded from consideration due to lack of preservation of the necessary skeletal element or because of taphonomic erosion of the outer table of the cranial vault.

Cribra Orbitalia

Cribra orbitalia refers to porosities associated with the outer table of the eye orbits. The distinguishing feature of this pathology is its location. Although often grouped together, recent studies have shown that porotic hyperostosis and cribra orbitalia may actually have different etiologies (Walker *et al.* 2009). The fact that cribra orbitalia is more frequently found in skeletal assemblages than porotic hyperostosis supports this conclusion (Steckel *et al.* 2002b; Walker *et al.* 2009). As such, they are discussed separately here.

Like porotic hyperostosis, the bony response of cribra orbitalia is the result of hypertrophy of the marrow space. However, lesions that form in the eye orbits have a number of probable causes that are not shared by lesions of the cranial vault. Walker *et al.* (2009) discuss the relation of a deficiency of both vitamin B_{12} and vitamin C to the presence of cribra orbitalia. The authors point out that cribra orbitalia is manifested by either an expansion of the marrow cavity or subperiosteal inflammation. The latter of these responses is more frequently associated with young subadults as the periosteum of children is less firmly attached to underlying orbital bone than in adults. They also note a connection between the presence of orbital lesions and scurvy. The conclusion drawn is that the deficiency in vitamin C further weakens the attachment of the periosteal tissue layer, allowing subperiosteal hematomas to form (Walker *et al.* 2009). Observations of cribra orbitalia, particularly active lesions in subadults, may be caused by the presence of multiple nutritional deficiencies, infectious processes, or trauma to the orbital tissue layers.

Observations of cribra orbitalia were recorded during the principal investigation of the MCIG cemetery. These observations include evidence of porosity within the eye orbits of an individual. When present, the status of the pathology is categorized as follows: active at the time of death; healed; or a mixed response. Individuals with at least one observable orbit are included in this analysis. The severity and status of any orbital lesions is noted. Individuals were excluded from consideration when neither orbit was preserved. In addition, individuals were excluded when the observed porosity was the result of taphonomic factors.

Long Bone Metrics

Stress, particularly inadequate nutrition, and stature have been shown to be linked in numerous studies (Larsen 1997). The examination of changes in adult stature over time is often used to assess the impact of shifts in subsistence strategies within a population. Documented changes also give an indication of the population's adaptation to long-term stressors and resistance to pathogenic stressors. The assumption of such studies is that the population in question is a true population with relative stability over time. As stated earlier, the MCIG sample is not such a population.

Regardless, the inclusion of maximum femur lengths for both the adults and the subadults is added to the study for several reasons. While the MCIG sample does not represent a single population, the context, both temporally and socioculturally, is comparable to other similar samples. As such, the calculation of average adult stature from the maximum femur length corresponds to like measures in the comparable studies selected for this project. A stated objective of the *Global History of Health Project* is the collection of stature measures for both males and females to add to a growing body of literature of comparing populations across space and time. The measures of adult stature for the MCIG sample are not, however, included in the assessment of overall health for the sample.

The measure of subadult femur length is included to provide additional information on the health status of the subadult sample. The comparison of skeletal growth to dental development is used to discuss the nutritional status of the subadult sample in comparison to other skeletal samples. For each sample, a scatterplot of subadult femur length plotted against dental age in years is created. In particular, the younger segments of the subadult sample, those under 5 years of age, will be examined to address the periods in which growth and development are most vulnerable (Goodman and Martin 2002).

The measures of adult stature used for this project are based on the regression formula developed for maximum femur length by Trotter and Gleser (Trotter 1970), which can be found in Appendix A. The measures of subadult femur length are based on the standards developed by Fazekas and Kosa (1978) and Maresh (1955; 1970). Measurement of the diaphyseal length was considered only for individuals with unfused epiphyseal ends.

Nonspecific Infection

The human skeleton can exhibit various changes as a result of exposure to stressors. Usually, these stressors stem from environmental or cultural events and appear as physiological disruptions in the skeletal tissues. These factors can affect the health of any individual. In particular, environmental variables often considered include the subsistence strategies practiced, the diet of a specific population, and the pathogens that affect the population. When the etiology of a response to infection cannot be directly tied to a disease process, the reaction can be used as evidence of a generalized response to an external stressor.

Periostitis and Osteomyelitis

The first skeletal tissue to be affected by any infectious process is often the periosteum. When this reaction involves an inflammatory response in the bone tissue, it is generally referred to as a periosteal reaction (Larsen 1997; Steckel and Rose 2002b). Reactions in the periosteum can be caused by several factors: infection; non-infectious systemic stressors; or trauma (Ortner 2003). The determination of both the location of the periosteal reaction and the number of skeletal elements involved helps to identify whether the reaction is the result of a systemic or localized stressor.

As discussed above, periosteal reactions can take many forms. Two types of bony reactions are considered in this study: periostitis and osteomyelitis. Periostitis refers to an inflammatory response in the periosteum of a bone due to either trauma or infection. Its involvement is limited to only the outer, cortical bone (White 2000; Ortner 2003). The most common site affected by periostitis is the tibia. Most consider the location of the tibia, near the surface of skin, to be the causative factor in the frequency of its involvement (Goodman and Martin 2002; Ortner 2003). The tibiae are more prone to insult caused by trauma or infection introduced through breaks in the skin due to its location.

Osteomyelitis, like periostitis, involves an inflammatory response in bone that is attributed to either trauma or infection. However, unlike periostitis, this pathology involves the medullary cavity (White 2000). It is often differentiated by a narrowing of the marrow cavity, the presence of cloacae (drainage canals), or the presence of involucrum (reactive bone formation around dead bone) (Ortner 2003).

Periostitis and osteomyelitis are included as indicators of health in this study, specifically as indicators of nonspecific infectious processes. More often than not, infectious disease leaves behind little evidence of its impact on human populations. When evidence of the body's response to disease is found, the ability of investigators to infer specific causes for the reaction is limited as many chronic infections produce the same reactions in skeletal tissues. It is important to note that, while these pathologies are discussed here as a disease entity independent of other pathologies, periostitis and osteomyelitis are also included in discussions of specific infectious diseases (Ortner 2003).

For the purposes of this study, reactions indicative of periostitis or osteomyelitis are considered. Observations from all long bones, the clavicles, and the ribs are used to address the prevalence of periosteal reactions. As part of this analysis, tibial reactions are considered separately from responses found on other skeletal elements due to their frequency as a site of periostitis. The data collected during the principal investigation of the MCIG sample classified the bone formation as one of the following: reactive woven bone; sclerotic or remodeled bone; or both woven and sclerotic bone. Osteomyelitis is considered when a bony response could be seen to have affected the marrow cavity as well as periosteal tissue, and cloacae or involucrum are observed. Reactions attributed to localized trauma were excluded from consideration.

Specific Infectious Diseases

An important focus in the field of paleopathology is the development and application of diagnoses through which specific pathogens and disease pathways can be differentially separated. These models, usually derived from clinical samples, have increasingly found their way into the research areas of paleopathology and bioarchaeology. While non-specific indicators of stress give a general overview of the impact of stress on a population, the patterns and indicators associated with a number of specific diseases can shed light on the health of both populations and individuals. Two specific pathologies are highlighted below. The focus on these diseases addresses the research expectation that skeletal evidence for specific pathogens would be present in the MCIG skeletal sample based on its presence within the city of Milwaukee. They are also used to address research questions related to the comparison of skeletal evidence for infectious disease and established prevalence rates for such diseases.

Tuberculosis

Tuberculosis (TB) is an infectious disease that develops from the bacterial genus *Mycobacterium*. Although there are several species of bacteria that can affect humans, they share a primary mode of transmission, namely through the respiratory system (Ortner 2003; Roberts and Buikstra 2003). A brief description of the disease's inclusion in the current study is below.

Identifying individuals with tuberculosis in the MCIG sample is of particular interest given its prominence as a known cause of death within the city of Milwaukee. As highlighted in Chapter 2, tuberculosis killed more people in the city than any other single disease, with an average of 6.0 percent to 11.6 percent between 1900-1920 (Leavitt 1982). It is also one of the few infectious processes that can leave skeletal evidence of the disease, and for which diagnostic criteria for identifying the pathogen appears in published literature.

Evidence for tuberculosis within the MCIG sample was closely examined. Diagnostic pathologies of the disease, when observed, were recorded and other possible diagnoses were considered, including brucellosis and fungal infections. Clark et al. (1987) found that the spine, ribs, and hips were most commonly affected by multifocal bone loss from TB. Likewise, Roberts and Buikstra (2003) found that the spine was the most frequently affected site. They note that lytic lesions involving the spine are diagnostic of TB, while the involvement of other areas such as the ribs are simply suggestive of the disease. When the spine is affected, the resulting changes are often referred to as Pott's Disease and are associated with vertebral collapse. The following observations, derived from Ortner (2003) and Roberts and Buikstra (2003), are used to assess pathological conditions that may be indicative of TB:

1) Lytic or erosive lesions present in the spine, particularly the vertebral bodies of the lower thoracic and upper lumbar vertebrae.

2) Vertebral collapse with resulting kyphosis seen with the destruction of the vertebral bodies.

3) Proliferative lesions observed on ribs.

4) In addition to spinal involvement, bone loss observed in other skeletal elements, particularly the nasopharyngeal area, hand and foot bones, and the joints.

At the time of the principal investigation, only non-destructive methods could be used on the MCIG sample. This precluded the ability to use more definitive biomolecular methods to identify pathogen aDNA within the skeletal material.

A differential diagnosis of tuberculosis requires some caution as the skeletal evidence for the disease can also occur with other infectious diseases and non-infectious etiologies. Pathological conditions producing similar reactions include brucellosis, fungal infections such as blastomycosis, osteomyelitis, typhoid spine, healed vertebral fractures, septic arthritis, malignant bone tumors, Paget's disease, and ankylosing spondylitis (Aufderheide and Rodríguez-Martín 1998; Ortner 2003). When seen, bone lesions associated with tuberculosis generally show unifocal destruction and cavitation of skeletal elements such as the vertebrae. Little or no reactive bone is usually present (Ortner 2003). Aufderheide and Rodríguez-Martín (1998) cite the primarily destructive nature of tubercular lesions as an important distinction between tuberculosis and other diseases such as brucellosis, which often presents evidence for bone formation as well as destruction. The location and type of lesions seen are used as the primary measures for identifying tuberculosis within the skeletal sample.

Based on evidence from contemporary populations, Roberts and Buikstra (2003) list the most frequently affected age cohorts to be birth to 5 years, 15-30 years, and 60 plus years. They point out that the disease impacts individuals during periods of increased vulnerability. As such, when evidence of a probable infection could be identified, age and sex-specific prevalence rates were calculated. As a note, both the presence and absence of tuberculosis are examined with these demographic variables in mind.

Treponemal Infections

Treponemal infections are usually classified as four specific diseases: venereal syphilis; yaws; pinta; and non-venereal (endemic) syphilis (Goodman and Martin 2002). Caused by the bacterial genus *Treponema*, each of these is considered a distinct disease with a limited geographical range. Venereal syphilis would be the only exception as it is seen worldwide (Ortner 2003). Two types of venereal syphilis are *acquired syphilis* (transmitted through sexual contact) and *congenital syphilis* (transmitted from mother to fetus during development) (Ortner 2003). Both of these types were considered for the city of Milwaukee and the surrounding community during the principal investigation.

Like tuberculosis, treponemal infections are considered for this study because of their presence in associated historical records for the Milwaukee county grounds. Bony response to treponemal infections tends to affect skeletal elements close to the surface of the skin. As such, skeletal reactions are most frequently seen in the cranial vault, nasal cavity, and the tibia (Ortner 2003). However, the pathological responses seen in treponemal infections are also commonly associated with nonspecific or generalized infection. Thus, a differential diagnosis of a treponemal infection is often difficult. The criteria used in making such a diagnosis, by necessity, includes conservative observations of what is pathognomonic for syphilis.

Powell and Cook (2005a) discuss the importance of the skull in diagnosing treponemal infections. Syphilic lesions, seen in clinical settings, in the nasal region and cranial vault are considered the most diagnostic pathologies for the disease (Ortner 2003; Powell and Cook 2005a). In archaeological settings, the bony response to this disease is manifested by excessive bone formation on the skeletal elements involved (Ortner 2003). Skeletal involvement is only seen in adults with tertiary or third-stage syphilis. Given the lapse between initial infection and skeletal response, an individual may be affected by treponematosis without bony evidence for a time period of 2 to 10 years (Ortner 2003). The following criteria, derived from Powell and Cook (2005a; 2005b) and Ortner (2003), is used when considering pathological conditions indicative of syphilis in the adults:

1) Cranial lesions, active or healed, are present on the cranial vault. These lesions may be present as the "caries sicca" sequence, including focal cavitations when active and sclerotic radial (stellate) scars when healed. (Ortner 2003)

2) Nasal or oropharyngeal lesions are present.

3) Bone formation or periosteal apposition observed on the tibiae, which may include a "sabre-shin" appearance caused by anterior bowing of the tibiae. (Baker 2005)

4) Evidence for periosteal apposition is present on multiple long bones, which may include periostitis, periosteal plaque, and cortical thickening. (Weaver *et al.* 2005)

In the subadults, the following pathologies are considered for a diagnosis of congenital syphilis:

1) Dental pathologies present, particularly Hutchinson's incisors or Moon's (mulberry) molars.

2) Focal cranial lesions present.

3) Destructive lesions observed in the nasal region.

4) Periostitis present on long bone diaphyses, which may result in "saber tibia", where bone is built up on the anterior surface of the bone. (Ortner 2003)

Infectious vs. Degenerative Diseases

The role and impact of infection, both generalized and specific, on the sample versus the presence of degenerative processes is also considered. As discussed in Chapter 1, studies of disease in epidemiology often look at the epidemiological transition, the transition whereby degenerative diseases replaced infectious diseases as the leading causes of death. These degenerative diseases include: heart disease, diabetes, and cancer. While most often not directly tied to causes of death, osteoarthritis, osteoporosis, and rheumatoid arthritis are degenerative diseases that can impact the skeleton. The identification of infectious and degenerative processes in skeletal samples is discussed in the subsequent pages. These measures are used to address research questions related to both public health in American cities and defining health within the sample, particularly the evidence seen that reflects upon an epidemiological transition.

Infectious Agents

Infectious processes may include those caused by bacteria, mycosis, viral, or parasitic agents (Ortner 2003). These infectious agents can reach the skeletal structure of the body in several different ways including the following: direct infection through traumatic injuries; direct extension from soft tissue infections; and through the bloodstream as a result of a septic infection (Ortner 2003). In most infections that affect the bony tissue, the disease process is represented by either bone loss or bone formation as the body responds to the presence of the infectious pathogens.

Bone loss and bone formation are often used to single out those infections directly resulting from disease processes and those associated with traumatic injury. In both cases, the most commonly affected tissue is the periosteum. The location of these pathological conditions contributes highly valuable information. In traumatic events, the bony response to infection tends to be a localized event (Ortner 2003). As such, one of the defining features of infectious diseases is the involvement of multiple specific bony elements.

For this study, individuals who exhibit systemic infectious processes are singled out. Inclusion in the set was dependent on the presence of bone loss and/or bone formation skeletal responses. Specifically, those remains that exhibit multiple reactions, including a secondary response such as porotic hyperostosis, at multiple locations are selected for consideration. The responses are also highlighted because of the location of the reactive tissue, namely those that affected the skull, long bones, hands and feet, pelvis, vertebral column, and ribs. Individuals were excluded from consideration if only one element was affected or if the level of preservation prevented observation of the most commonly affected tissues. In addition, individuals with multiple reactions that could be attributed to traumatic origins were excluded.

Degenerative changes

Osteoarthritis is one of the most common causes of skeletal pathology. The skeletal response to this pathology includes a breakdown of articular cartilage, reactive bone formation (particularly in the subchondral bone), and new bone growth at the margins of the joints affected (Ortner 2003). These degenerative changes may develop for a number of reasons, including: activity; trauma; genetic predisposition; or variables such as age, ancestry, and body weight. Regardless, the most significant factor in the development of osteoarthritic changes is activity-based stress (Larsen 1997; Ortner 2003). The development of osteoarthritic reactions can be seen as an indirect measure of the amount of stress an individual encounters and the body's ability to respond to stressors.

As discussed earlier, the MCIG sample includes a large number of individuals from Milwaukee's industrial labor force. Richards (1997) presents occupational information from an 1896 report on the County Almshouse. The occupations of laborer, farmer, and housewive account for almost three-fourths of the individuals included in the report. It reflects a group that would have been exposed to a high level of activity-based stress, and highlights a pattern of occupation that is seen throughout the cemetery's time in operation. As such, degenerative changes are included in the analysis of health for the MCIG sample.

Of particular importance to studies of osteoarthritis is the observation of joint degeneration or disease. This information was included to discern observable age and sex patterns with regards to this pathology. Where applicable, age and sex-specific prevalence rates are compared with similar samples. Data collected during the principal investigation, according to *Standards* (1994), on degenerative changes to the limb joints and the joints between vertebral bodies is used to measure the presence of osteoarthritic changes. The limb joints examined include: shoulders, elbows, hips, knees, wrists, and ankles. The location of such changes and the degree to which the joint was affected is noted. Degenerative changes associated with obvious trauma, usually localized, were excluded from consideration.

Measuring Infectious vs. Degenerative Processes

Observations of both infectious and degenerative changes are combined with available historical evidence in order to assess their impact on the MCIG sample. The number of individuals who exhibit evidence of infectious processes is compared to the number of individuals listed in the Milwaukee County Grounds Burial Record with an infectious disease as a cause of death. In addition, the number individuals with a differential diagnosis of tuberculosis is compared to the number of individuals listed with tuberculosis from the burial records.

A frequency table was generated to examine the overall impact of infection on the both the skeletal sample and the sample from the burial record. Each individual in the skeletal sample is categorized as either exhibiting the presence or absence of bony responses to infection. As the measures mentioned above concern samples that are related instead of independent of one another (both samples contain the same individuals), this dissertation looks at nonparametric tests for related samples. In this case, the McNemar test for related samples is used to test for differences seen between the skeletal evidence for infectious disease and the historical evidence based on causes of death listed in the burial registry. The McNemar test uses the chi-square distribution to look at differences between the samples, with a null hypothesis that the variables, sample source and presence of infectious disease, are not significantly different. It is primarily used when the observations between related samples consist of categorical data, instead of continuous data (Hinton *et al.* 2004). The Statistical Package for the Social Sciences (SPSS) is used for the analysis. The results are reported as a chi-square test statistic with significance at the $p < 0.05$ level (Hinton *et al.* 2004).

While the presence of osteoarthritic or degenerative changes is related to stress, they are not necessarily comparable to epidemiological studies (Larsen 1997). As such, the measurement of the impact of degenerative changes is two-fold. One measure compares the rates of degenerative disease seen in the MCIG sample with other comparable samples. The statistical methods used in these comparisons are explained more thoroughly in the subsequent section, "Measuring Indicators of Health". A second measure utilizes the available historical evidence to look at the recorded impact of degenerative disease within both the burial sample and the larger community.

The primary measure used to assess the role of infectious and degenerative processes on the MCIG sample is the causes of death listed in the associated burial records (1882-1925). The inclusion of cause of death information in the Register of Burial was inconsistent prior to 1908. After 1908, every burial entered into the Register had associated cause of death information. Another measure used is the *City of*

Milwaukee Annual Reports (1861-1874) and later the *Milwaukee Board of Health Annual Reports* (1875-1932). These reports include information about mortality and morbidity rates within the city of Milwaukee. As such, they are used to identify temporal trends or shifts in the leading causes of illness and death within the community at large.

Measuring Indicators of Health

For the indicators of health mentioned in the preceding pages, the number of individuals exhibiting a certain pathology and the frequency with which the pathology occurred in age and sex cohorts was developed. Frequencies are considered only for those individuals who had the appropriate skeletal elements present for observations of a specific pathology. For example, the count of individuals exhibiting cribra orbitalia is measured out of the total number of individuals with one or more orbits preserved and available for observation.

For comparisons within the MCIG sample, the frequency data are used to measure differences between subsets within the sample. Pearson's chi-square was used to test for significance at the $p < 0.05$ level (Hinton *et al.* 2004). The null hypothesis is that the variables being examined are unrelated. As such, a significant result indicates that there is an association between variables (Reynolds 1984). The odds ratio was also calculated for each comparison as a risk estimate. While the chi-square test is used to show associations between variables, the odds ratio is used to examine the directionality of the relationship between variables.

Two measures of disease frequency commonly used in epidemiological studies are incidence and prevalence rates. Incidence rates refer to the number of new cases divided by the total number of years individuals in a population would be at risk for a specific disease. In contrast, prevalence rates measure the total number of cases seen divided by the total number of individuals in a population (Waldron 2007). Skeletal assemblages provide information on neither new cases of a disease or the number of years individuals would be at risk. As such, the calculation of prevalence rates from human remains is the only measure of disease frequency applicable (Waldron 2007). For this dissertation, prevalence rates are reported as the rate of disease observed per 1,000 individuals.

The calculated prevalence rates were selected based on their contribution to both intra-study and inter-study comparisons. Age and sex-specific prevalence rates for the adults and age-specific prevalence rates for the subadults are calculated to examine the prevalence rates of various stresses on different segments of the sample. These measures were calculated for use in the common odds ratio statistic described below.

For between-group comparisons, the common odds ratio is used. These groups include the MCIG sample and the comparative samples used in this study. The odds ratio uses the age-specific or sex-specific prevalence rates for two samples. It is particularly useful in the comparison of prevalence rates when age structure and sample sizes are not consistent (Klaus and Tem 2009). The following equation illustrates the comparison of prevalence rates, where p_1 represents an age-specific or sex-specific rate from one sample and q_1 represents the rate from another:

$$\frac{p_1/(1-p_1)}{q_1(1-q_1)}$$

(Bachman and Paternoster 1997; Waldron 2007)

The common odds ratio is a summary statistic that takes the sum of odd ratios for all age categories. The confidence interval at 95% was calculated for each common odds ratio to test for significance at the $p < 0.05$ level. If the confidence interval included 1, then the prevalence rates of the two samples was determined to include the unity of the samples and hence did not show a significant difference (Waldron 2007). This measure is used to compare the prevalence rates between each of the samples used in this study.

Comparative Samples

The use of comparative studies in assessments of health is important because of the context it provides in discussions of high or low levels of stress on any group. The intra-study results for the MCIG sample are useful for addressing differences seen in regards to variables such as age and sex. However, its comparison to other similar studies provides a baseline for discussions of significance of the results.

The following studies were selected because of the temporal and sociocultural similarity to the sample from Milwaukee. Collectively, these studies encompass a timeframe beginning in 1826 and ending by 1870 at the beginning of more aggressive public health policies within the nation's urban areas. These samples include: the Dunning Poorhouse cemetery, Chicago, IL; the Monroe County (MonCo) Poorhouse cemetery, Rochester, NY; and the Voegtly Cemetery, Pittsburgh, PA. While the Monroe County Poorhouse sample and Dunning Poorhouse sample reflect institutional samples, the inclusion of Voegtly cemetery adds the component of assessing a community-based sample. These samples, summarized in Table 5, are used to address research questions related to the comparison of similar samples.

Table 5: Summary of Study Samples

Cemetery	MCIG	%	Dunning[1]	%	MonCo[2]	%	Voegtly[3]	%
Years in Operation	1882-1925		1851-1869		1826-1863		1833-1861	
Archival Evidence	Y		Y		Y		Y	
Adults	985	*59.7*	72	*60.0*	199	*67.2*	171	*23.0*
Subadults	588	*35.7*	48	*40.0*	81	*27.4*	385	*51.7*
Undetermined	76	*4.6*	0	*0.0*	16	*5.4*	188	*25.3*
Total	1,649	*100.0*	120	*100.0*	296	*100.0*	744	*100.0*

1 Dunning Database and original data collection Sheets courtesy of Anne Grauer

2 Lanphear 1988

3 *Human Remains from Voegtly Cemetery* 2003

Summary

The methods used with this study are based upon accepted measures of health within published literature as discussed in Chapter 1. In addition, the inclusion of comparative samples in the overall analysis influenced which measures are featured. The goal of the comparative analysis is to examine the indicators of health between samples using the measures that the samples have in common. Each skeletal study, including the current one, was influenced by a variety of factors during the course of investigation. These factors included: levels of preservation; timeframe for completion of the analysis; the availability of destructive versus nondestructive analysis; and how data collection was categorized and recorded. As such, no two studies are identical. The statistical tests chosen attempt to limit the impact of differences in both age structure and number of recovered adults and subadults from each sample. As MCIG skeletal sample is the primary sample, the next chapter will look first at presence and impact of the selected indicators of health on this sample. Appendix # contains the exact scoring system used to categorize the data from the MCIG sample in order to compare it to the other samples used in this study.

Chapter 5 – Results from the MCIG sample

The results of this dissertation are divided into two chapters. This chapter addresses the primary sample, the Milwaukee County Institution Grounds (MCIG) cemetery, while the next chapter looks at the results of comparisons with similar samples. Chapter 6 also looks at a comparison of the MCIG skeletal analysis and the associated burial records.

The MCIG skeletal sample is used for the current study because of its potential to address research questions related to skeletal health. The size of the sample provides a large amount of data on the pathological conditions and disruptions to growth that can be seen in human skeletal remains. It also presents a wide range of variation in the preservation of those interred in the cemetery.

As the discussion of skeletal health in this study relies on comparisons made between age and sex cohorts both within the MCIG sample and other similar samples, a study sample was selected from the excavated remains available for study. As discussed in Chapter 4, this sample was selected to focus on those individuals that could provide the greatest amount of information for comparative purposes, primarily those individuals for which age and sex determinations could be made. Skeletal studies of health typically report by these age and sex divisions. The adult and subadult samples selected include random samples from each excavated area of the cemetery and provide a sufficient number of individuals for statistical assessment. This author has also had the opportunity to assess the entire collection of excavated remains from the MCIG cemetery, and as such has found the sample used in this study to be representative of the sample as a whole.

The skeletal sample from the MCIG cemetery was examined for the frequency of several indicators of health: linear enamel hypoplasias, porotic hyperostosis, cribra orbitalia, long bone metrics, nonspecific infections, specific infections, and overall impact of degenerative processes. These indicators are examined among the adult and subadult samples. Differences based on age and sex groups for the adults and age groups for the subadults are also discussed. As such, the chapter begins with the demography of the skeletal sample and the age categories established for comparative purposes.

Demography of Skeletal Sample

Subadult Demography

The subadults are divided into three age categories. The division used in this study took into consideration the age categories used in other comparative samples and the sample size of each cohort. For example, the juvenile cohort encompasses a large amount of variation in growth and development, but is large enough for significance testing. Age categories set up around a 5-year center could be used for all the samples included in the analysis. The categories are as follows:

Infant (Less than 1 year)
Child (1-4.9 years)
Juvenile (5-19.9 years)

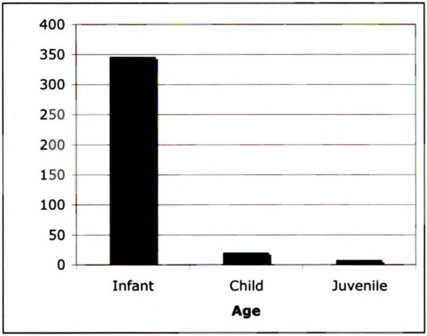
Table 6 and Figure 11 show the number of individuals in each age category. Estimations of sex were not established for the subadult sample because of the ambiguity of features used in such estimations and the lack of acceptable standards for sexing subadult remains (*Standards* 1994). The infant age category shows the largest number of individuals. The burial registry provides evidence for a large number of infants from the city proper being interred on county grounds. These include stillborns from Milwaukee's various hospitals.

The large number of infant deaths seen in the city is reflected in the skeletal sample.

Table 6: Subadult Age Demographics

Age	Number (*n*)	%
Infant	346	88.3
Child	20	5.1
Juvenile	7	1.8
Unknown	19	4.8
Total	392	100.0

Figure 11: Subadult Age Estimations



Adult Demography

The adult age categories are established based on *Standards* (1994). Estimated age at death in the adult sample was established for both adult males and adult females, with a total of 406 males (76.5%) and 57 females (10.7%). Both males and females exhibit a similar age structure, with the highest frequency of individuals estimated as middle-aged adults, 35-49 years at death. The adult sample also includes 28 individuals with ambiguous sex and 40 individuals for whom age and sex could not be determined. 'Ambiguous' sex is used here to indicate those burials for which features used in estimations of sex were present but exhibited both male and female characteristics, as compared to 'unknown' sex where there was insufficient evidence to assess the sex of the individual. Table 7 and Figure 12 summarize the demographics of the adult skeletal sample.

Table 7: Adult Age and Sex Demographics

Age and Sex		**Number (*n*)**		**%**	
Male	Young	406	56	76.5	10.5
	Middle		271		51.0
	Old		79		14.9
Female	Young	57	14	10.7	2.6
	Middle		28		5.3
	Old		15		2.8
Ambiguous	Young	28	4	5.3	0.8
	Middle		21		4.0
	Old		3		0.6
Unknown Age and Sex		40		7.5	
Total		531		100.0	

Figure 12: Adult Sex Estimations

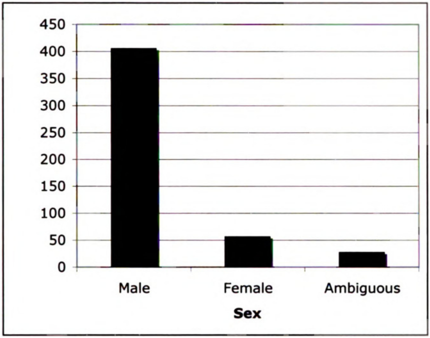


Figure 13: Adult Age Estimations for Males and Females

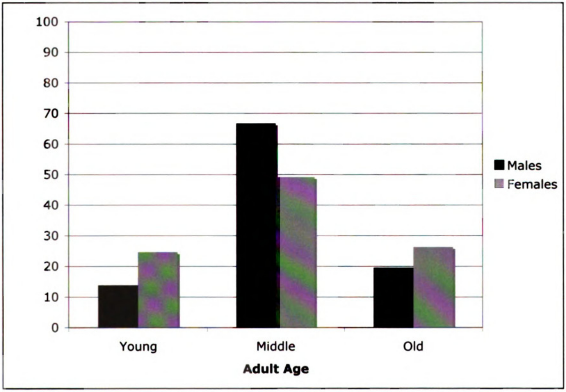


Figure 13 shows the percentage of each age cohort for both males and females. A total of 271 individuals are classified as a middle-aged adult male. Fifty-six are aged as young adults and a slightly higher 79 individuals are aged as older male adults. A total of 28 individuals are classified as a middle-aged adult female. The female group exhibited an almost equal number of individuals aged as young adults and old adults with 14 individuals and 15 individuals respectively.

The large number of middle-aged males again reflects the inclusion of individuals from the city of Milwaukee. Historically, the city was comprised of a large number of immigrant industrial workers (Gurda 2006). This particular group would have been more likely to be exposed to high levels of stress and impoverished living conditions.

Defining Health within the Sample

The ability to observe indicators of health within the MCIG sample was largely based on the preservation of different bones and skeletal features. The inventory for each set of individual remains is used to assess what skeletal elements are more frequently preserved. For the 531 adult remains included in this dissertation, the long bones and hands and feet are the most frequently preserved bones. The anterior teeth are the least preserved skeletal element as only 37.1% of the adult remains include these teeth. Table 8 shows the frequency of each skeletal element in the adult sample. For example, of the 531 adult individuals examined, 497 individuals or 93.6% of the sample have at least one observable ulna. The bones included in the table are those used to address observed health within the skeletal sample.

Like the adults, the subadult sample used in this dissertation exhibited varying levels of preservation. The most frequently preserved bone is the femur, followed by the tibia and humerus. The dentition in the subadult sample showed a higher level of preservation than the adult sample as 60.2% of the sample has observable dentition. When looking at indicators of health, the least preserved bones are the parietals. Table 9 shows the frequency of each skeletal element needed to assess the health of the subadult sample.

Table 8: Frequency of skeletal elements in the adult sample

Skeletal Element	**Frequency (%)**
Ulna	93.6
Radius	93.0
Femur	92.8
Humerus	92.7
Hands	92.5
Tibia	90.8
Fibula	90.0
Clavicle	89.5
Feet	89.3
Parietal	86.3
Occipital	85.7
Scapula – Glenoid Fossa	85.5
Cervical Vertebrae	85.3
Frontal	84.6
Frontal – Eye Orbits	84.4
Thoracic Vertebrae	83.2
Lumbar Vertebrae	75.5
Ribs	75.3
Dentition – Anterior Teeth	37.1

Table 9: Frequency of skeletal elements in the subadult sample

Skeletal Element	Frequency (%)
Femur	90.8
Humerus	87.0
Tibia	76.8
Frontal	64.5
Dentition	60.2
Frontal – Eye Orbits	51.5
Parietal	27.0

Stress and Disruptions to Growth

Linear Enamel Hypoplasias

Out of 531 individuals in the adult sample, the number of remains with observable anterior teeth (central incisors, lateral incisors, and canines) is 197 (37.1%). These individuals have at least two mandibular or maxillary anterior teeth. Linear enamel hypoplasias (LEH) are observed in 78 individuals out of the 197 with observable dentition. The total frequency of the hypoplasias is 39.6%. The calculated prevalence rate is 395.9 per 1000 individuals.

The subadult sample, consisting of 392 individuals, has a total of 236 (60.2%) individuals with observable anterior teeth and canines. Linear enamel hypoplasias (LEH) are observed in 34 individuals out of the 236 with observable dentition. The frequency of hypoplasias within the sample is 14.4%. The calculated prevalence rate is 144.1 per 1000 individuals.

The presence of LEHs, like the other indicators of health, is presented here by individual (a discussion of reporting by individual vs. tooth category can be found in

Chapter 4). The frequency of observed linear enamel hypoplasias is higher than other paleopathological observations. However, the level of preservation observed with the adult dentition, particularly the anterior teeth and canines is more highly variable between burial lot series than other skeletal features. For example, the remains included in the 7000s series exhibited few observable anterior teeth due to either missing dentition, substantial wear on the occlusal surface of most teeth, or caps and fillings on the teeth present. The 3000s, 5000s, and 9000s exhibit the best preservation of anterior teeth and most observable LEH. Table 10 shows the number of individuals with observable LEH out of the total number with observable dentition, the frequency of each in the adult and subadult samples, and the calculated prevalence rates.

Table 10: Frequency and Prevalence of LEH in the Adult and Subadult Samples

Pathology		**Present**	**Absent**	**Number (*n*)**	**Frequency (%)**	**Prevalence /1000**
LEH	Adults	78	119	197	39.6	395.9
	Subadults	34	202	236	14.4	144.1

Porotic Hyperostosis

Observations of porotic hyperostosis for the adult sample are separated by the cranial bones affected. While most studies of health include only observations of porotic hyperostosis seen in the parietal bones (*The Backbone of History* 2002), this study reports observed pathology in the occipital and frontal bones as well. A total of 458 individuals (86.3%), out of 531 in the adult sample, have at least one observable parietal. Twenty individuals, out of a total of 458 with at least one observable parietal, show evidence for porotic hyperostosis. The frequency of this pathology is 4.3% with an associated prevalence rate of 43.7 per 1000 individuals. A total of 455 individuals (85.7%) in the sample have an observable occipital. Eight individuals, out of 455, show evidence for porotic hyperostosis on the occipital bone. However, only one individual shows occipital involvement without any evidence for porotic hyperostosis on either the frontal or parietal bones. The remaining seven individuals show evidence for porotic hyperostosis on the parietal bones as well as the occipital bone. A total of 449 individuals (84.6%) in the sample have an observable frontal bone. Fourteen individuals, out of 449, showed evidence for porotic hyperostosis on the frontal bone. Like the occipital, only two individuals show frontal involvement without any evidence present on the other cranial vault bones. The remaining twelve individuals show evidence for porotic hyperostosis on the parietal bones as well as the frontal bone.

A total of 100 individuals (27.0%), out of 392 in the subadult sample, have at least one observable parietal. Twelve individuals, out of a total of 100 with at least one parietal, show evidence for porotic hyperostosis. The frequency of this pathology is 12.0% with an associated prevalence rate of 120.0 per 1000 individuals. While four individuals also show involvement of the occipital bone, all observations of porotic hyperostosis involve the parietal bones. Table 11 shows the number of individuals with observable porotic hyperostosis out of the total number with at least one parietal bone, the frequency of each in the adult and subadult samples, and the calculated prevalence rates.

Table 11: Frequency and Prevalence of Porotic Hyperostosis (Parietal) in the Adult and Subadult Samples

Pathology		**Present**	**Absent**	**Number (*n*)**	**Frequency (%)**	**Prevalence /1000**
Porotic Hyperostosis - Parietal	Adults	20	435	458	4.3	43.7
	Subadults	12	88	100	12.0	120.0

Cribra Orbitalia

The observations of porotic hyperostosis and cribra orbitalia are considered separately during this study. Observations of cribra orbitalia are reported for those individuals who have at least one observable eye orbit. A total of 448 individuals (84.4%), out of 531 in the adult sample, have at least one observable eye orbit. Six individuals show evidence for cribra orbitalia, out of the 448 with at least one eye orbit. The frequency of this pathology among the adult sample is 1.3%. The calculated prevalence rate is 13.4 per 1000 individuals.

A total of 202 individuals (51.5%), out of 392 in the subadult sample, have at least one observable eye orbit. Four individuals, out of 202, show evidence for cribra orbitalia. The frequency of this pathology is 2.0% with an associated prevalence rate of 19.8 per 1000 individuals. While the frequency of cribra orbitalia is lower in both adults and subadults than porotic hyperostosis, the subadult sample shows a noticeably lower prevalence rate despite a higher preservation rate for the eye orbits. A total of 202 subadults have at least one observable eye orbit compared to a total of 100 individuals with at least one preserved parietal bone. Table 12 shows the number of individuals with observable cribra orbitalia out of the total number with at least one eye orbit, the frequency of each in the adult and subadult samples, and the calculated prevalence rates.

Table 12: Frequency and Prevalence of Cribra Orbitalia in the Adult and Subadult Samples

Pathology		**Present**	**Absent**	**Number (*n*)**	**Frequency (%)**	**Prevalence /1000**
Cribra Orbitalia	Adults	6	443	448	1.3	13.4
	Subadults	4	198	202	2.0	19.8

Long Bone Metrics

Measurements of femur length were collected for both the adult and subadult samples. As stated in Chapter 4, adult living stature is calculated from the maximum femur lengths using Trotter's (1970) formulae for white males and females. For those individuals with intact femurs, the calculation of living stature is based on the measurement of the left femur. The right femur was used when the left was either fragmented or not present. The results are reported here by sex. These measures are not included in the overall assessment of adult health.

The femur is one of the best-preserved bones in the adult sample with 493 individuals (92.8%) having at least one femur present. The adult male sample has a total of 390 individuals with at least one femur. Of these, 328 or 84.1% of the males have associated measures of maximum femur length. Estimated stature for the 328 males range from 152.8 cm (5ft) to 193.5 cm (6ft 4in). The mean stature for this group is 170.1 cm (5ft 7in) with a standard deviation of 2.47 cm.

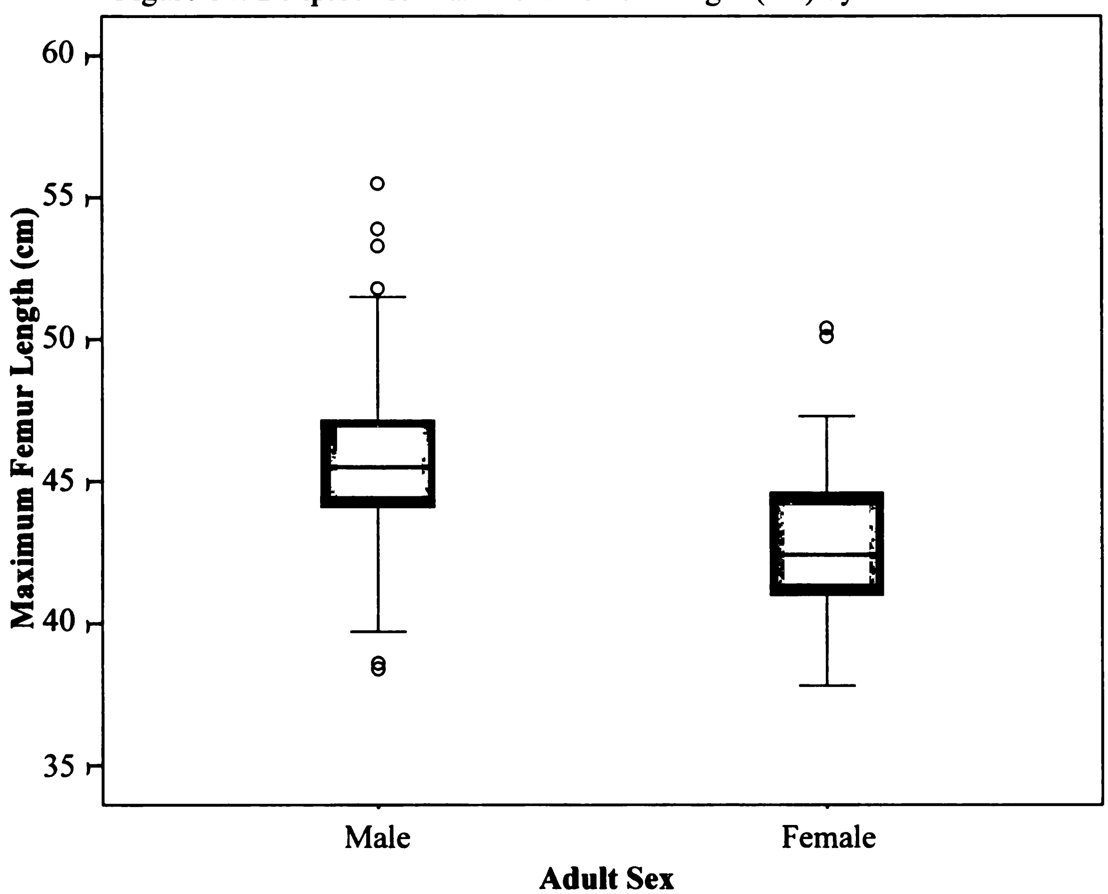
The adult female sample has a total of 51 individuals with at least one femur. Thirty-seven individuals (72.5%) have associated measures of maximum femur length. Estimated stature for the 37 females range from 147.5 cm (4ft 11in) to 178.6 (5ft 10 in). The mean stature for this group is 159.9 cm (5ft 3in) with a standard deviation of 7.24

cm. Table 13 shows the number of males and females with estimates of stature and the mean and standard deviation for the groups. Figure 14 shows the interquartile range for adult males and females.

Table 13: Adult Stature Estimations (in cm)

Sex	Number (n)	Mean Stature (cm)	Standard Dev. (cm)
Male	328	170.1	2.47
Female	37	159.9	7.24

Figure 14: Boxplot[1] of Maximum Femur Length (cm) by Adult Sex



[1] The top and bottom of the grey boxes represent the upper and lower quartiles while the thick black line represents the median. The whiskers represent the highest and lowest values that are not extreme values. The circles represent the outliers.

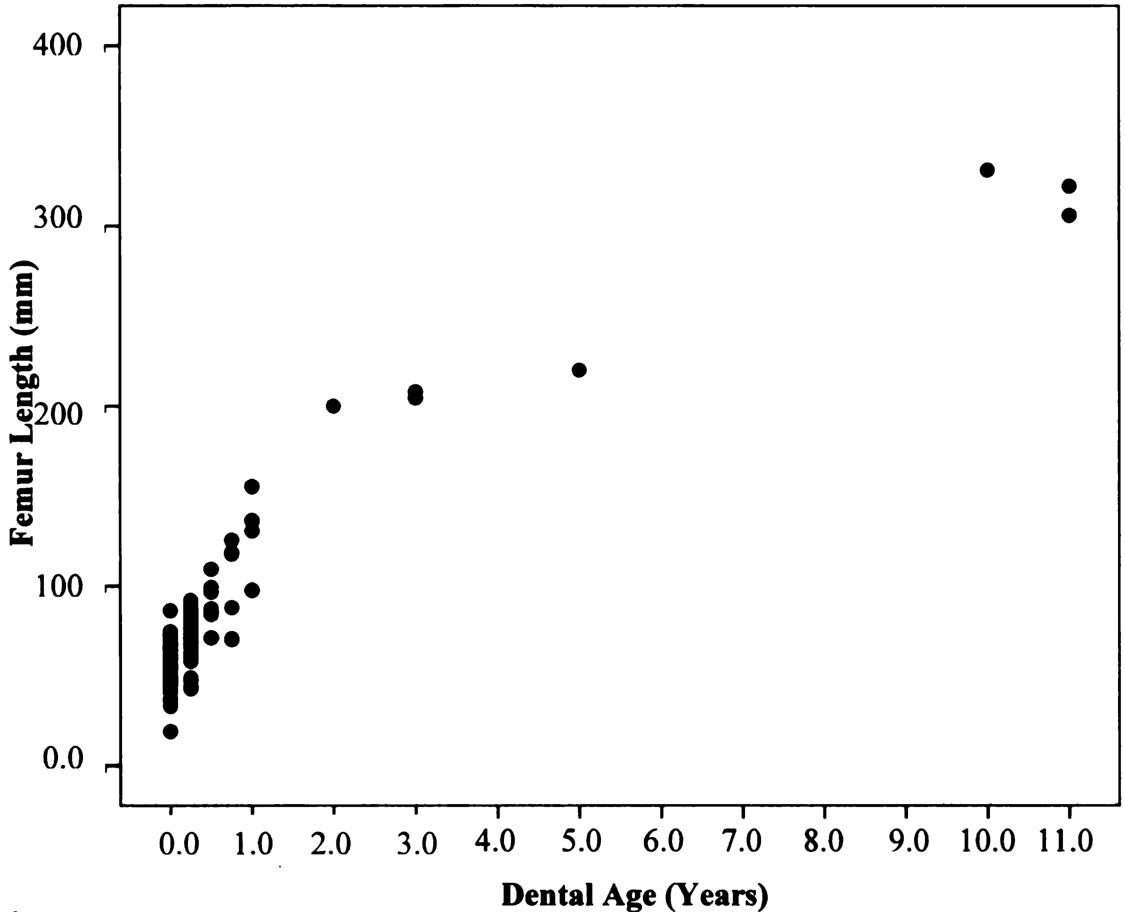
The infant age group has a total of 318 individuals with at least one femur present. Out of these 318 individuals, femur length could be determined for 189 infants (59.4%). Femur lengths for the infant group range from 18.95 mm to 130.50 mm.

The child age group has a total of 15 individuals with at least one femur present. Seven individuals (46.7%) have associated femur length measures. Femur lengths for the child group range from 97.50 mm to 208.00 mm.

The juvenile age group has a total of 7 individuals with at least one femur present. Only three individuals (42.8%) have femur length measures. The range for this age group is between 220.00 mm and 322.10 mm. The variation in femur length measures seen with this group represents the large range of ages encompassed in this category (5-19.9 years).

When available, femur lengths from the subadult sample are used as measures of growth for the subadult age groups. This measure is compared with the dental age estimations to examine the possible impact of nutritional and developmental stress between the MCIG sample and other comparative samples. A total of 200 individuals, or 51.0% of the sample, have both a measure of femur diaphyseal length and an associated dental age. This group consists of 188 infants, 7 children, and 4 juveniles. Figure 15 shows a scatterplot of subadult femur diaphyseal length in millimeters plotted against dental age in years. Given the size of the subadult sample aged at less than one year of age (88.3%), dental age categories of three-month intervals are established for those remains between birth and one year of age. After one year of age, one-year increments are used. The scatterplot shows a curvilinear shape, reflecting the pattern of rapid bone growth within the first 2 years of life (Mays *et al.* 2008).

Figure 15: Scatterplot of Subadult Femur Diaphyseal Length versus Dental Age[1]



[1] Dental age categories: 0.0=fetal, 0.25=birth-3 months, 0.50=3-6 months, 0.75=6-9 months, 1=9 months-1year, 2=2 years, 3=3 years, 4=4 years, etc.

Nonspecific Infection

Periostitis and Osteomyelitis

Evidence for periostitis was recorded for all long bones, the clavicles, and the ribs. Periostitis observed on the tibiae of both the adults and subadults is reported separately here as a nonspecific indicator of infection. Periostitis recorded on bones other than the tibia is included in observations of osteomyelitis and specific infections.

Individuals with at least one observable tibia are included in the frequency counts for periostitis. A total of 482 adult remains (90.8%) include at least one tibia. Thirty-one individuals, out of 482, show evidence of this pathology. The frequency of periostitis among the adult individuals is 6.4% with an associated prevalence rate of 64.3 per 1000 individuals.

A total of 301 subadults remains (76.8%) include at least one tibia. Four individuals, out of 301, show evidence of periostitis. The frequency of this pathology among the subadult individuals is 1.3%. The calculated prevalence rate is 13.3 per 1000 individuals. Table 14 shows the number of individuals with observable periostitis out of the total number with at least one tibia, the frequency of each in the adult and subadult samples, and the calculated prevalence rates.

Table 14: Frequency and Prevalence of Tibial Periostitis in the Adult and Subadult Samples

Pathology		Present	Absent	Number (*n*)	Frequency (%)	Prevalence /1000
Periostitis - Tibia	Adults	31	451	482	6.4	64.3
	Subadults	4	297	301	1.3	13.3

Also considered in the current study are observations of osteomyelitis, an inflammatory response in bone that involves the medullary cavity. Five individuals exhibit evidence for osteomyelitis. In all cases, the bony response affects multiple bones of the lower legs, showing evidence for a systemic infection. The reactions involve more than two-thirds of the diaphyses and include both woven and sclerotic bone formation. Three of the individuals exhibit severe bone formation on all of the long bones of the lower leg. All of the individuals were classified as middle-aged males.

Specific Infection

As stated in earlier chapters, bone is not easily impacted by infectious agents. When skeletal evidence of infection is present, it is usually indicative of a long-term or chronic response to a pathogen. While non-specific pathologies can provide information on the impact of stress on an individual or population, evidence for specific pathogens provides information about the types of stressors present. For this study, two specific pathogens are highlighted: tuberculosis and syphilis. According to the *Register of Burials at the Milwaukee County Poor Farm 1882-1925*, tuberculosis, syphilis, and congenital syphilis constitute three of the most frequent infectious causes of death within the sample.

Tuberculosis

Tuberculosis is listed as the primary cause of death for 355 individuals (12.3%) out of a total of 2,891 individuals with associated causes of death. When looking at only those causes of death that could be attributed to infectious processes, tuberculosis comprises 34.4% of the listed causes of death.

The diagnostic criterion used to assess the presence of tuberculosis within the skeletal sample is outlined in chapter 4. Six adults were found with pathology suggestive of tuberculosis. Of these, five individuals (1.1%) exhibit evidence of vertebral involvement in the thoracic vertebrae out of a total 442 individuals with at least one thoracic vertebrae present. Four individuals (1.0%) exhibit evidence of rib involvement out of the 400 individuals with at least one rib present. Table 15 lists the burial number, age and sex estimations, and elements affected for each of these individuals.

Table 15: Summary of possible tuberculosis infections

Burial #	**Sex**	**Age**	**Elements Affected**
2003	Male	20-34 years	Ribs
3039	Male	35-50 years	Ribs, Vertebrae, Pelvis, Long Bones
5035	Female	35-50 years	Ribs, Vertebrae, Pelvis, Long Bones, Mandible
5207	Male	35-50 years	Vertebrae
7230	Unknown	Unknown	Vertebrae
9263	Male	50+ years	Ribs, Vertebrae

Burial 2003 is estimated as a young adult (20-34 years) male. The inventory for this individual includes the cranial vault, fragmentary ribs and vertebrae (including thoracic vertebrae), and all long bones except the fibula. Evidence for multi-focal bone loss (lytic lesions) and reactive bone formation is present on one rib fragment. The lytic lesions are found on the pleural side of the rib or the side facing the lungs. A second rib fragment shows evidence of reactive bone formation on the pleural side of the rib. Although the presence of rib lesions is not considered diagnostic of a *Mycobacterium* infection, it has been suggested as a possible indictor of pulmonary tuberculosis (Roberts and Buikstra 2003). As pulmonary tuberculosis is the most frequently recorded form of tuberculosis within the burial records, Burial 2003 is included in the discussion for tuberculosis.

Burial 3039 is estimated as a middle-aged adult (35-50 years) male. The inventory for this individual includes the cranial vault, fragmentary ribs and vertebrae (including thoracic vertebrae), and all long bones. Evidence for unifocal lytic lesions is present on anterior, superior, and inferior surfaces of the 4^{th} through 7^{th} cervical vertebral bodies. A similar distribution of lesions is found among all thoracic and lumber vertebral bodies with the addition of lesions located on the lateral and posterior aspects of the bodies and in some cases the extension of lesions into the neural arches. Lytic lesions are also located near the head of both first ribs. In addition, destructive lesions are present on the superior aspect of the pleural side of one left rib, the posterior aspect of the manubrium, the posterior of the left scapula, the head of the left humerus, the posterior aspect of the right femoral neck and trochanter region, and the right iliac blade and sacroiliac joint. No reactive bone formation is associated with the lesions.

Burial 5035 is estimated as a middle-aged adult (35-50 years) female. The inventory for this individual includes the cranial vault, fragmentary ribs and vertebrae (including thoracic vertebrae), and all long bones. Evidence for multifocal lytic lesions is present on all aspects of the cervical, thoracic, and lumbar vertebrae, including the neural arches and spinous processes. The major lesions are primarily located on the anterior, superior, and inferior vertebral bodies of the thoracic and lumbar vertebrae. Lytic lesions are present on both right and left ribs, including the superior aspect of the first ribs and the head of the second ribs. The lesions are located on both the sternal and costal ends of the ribs and are primarily located on the inferior and pleural sides of the ribs. Reactive bone formation is associated with most of the lesions found on the third through twelfth ribs. Destructive lesions are also located on the medial side of the right mandible, the lateral aspect of the left clavicle, the lateral sides of both scapulae, both right and left upper long bones, the anterio-lateral aspect of both innominates and both iliac crests, and the sacrum.

Burial 5207 is estimated as a middle-aged adult (35-50 years) male. The inventory for this individual includes the cranial vault, fragmentary ribs and vertebrae (including thoracic vertebrae), and all long bones. Evidence for multifocal lytic lesions is present on the anterior, superior, inferior, and lateral aspects of the fragments of the first through ninth thoracic vertebrae, including the neural arches. The left eye orbit contains a small lesion with smooth edges on the superior aspect.

Burial 7230 is of unknown age and sex. The inventory for this individual includes fragments of the cranial vault, fragmentary ribs and vertebrae (including thoracic vertebrae), and fragments of all long bones. Evidence of multifocal lytic lesions is present on the anterior, superior, and inferior aspects of two adjacent thoracic vertebral bodies. No other evidence of infection is present.

Burial 9263 is estimated as an older adult (50+ years) male and is the only older adult to exhibit pathology indicative of tuberculosis. The inventory for this individual includes the cranial vault, fragmentary ribs and vertebrae (including thoracic vertebrae), and all long bones. Evidence for a large unifocal lytic lesion is present on the anterior aspect of one thoracic vertebral body. Destructive lesions are also located on the inferior aspect of two ribs fragments with a minimal amount of reactive bone formation associated with the lesions. Slight thickening of the diploic space in the cranial vault is also present.

The aforementioned individuals represent possible *Mycobacterium tuberculosis* infections. As a note, none of the individuals exhibited obvious signs of kyphosis or vertebral collapse known as Pott's disease, which is common in cases of spinal infections. Table 16 shows the frequency and prevalence rates of vertebral lesions indicative of TB for both adult sex groups and adult age categories while Table 17 looks at the frequency and prevalence of rib lesions.

Table 16: Frequency and Prevalence of Vertebral Lesions indicative of TB in the Adult Age and Sex-specific samples

Vertebral Lesions - TB		**Present**	**Absent**	**Number (*n*)**	**Frequency (%)**	**Prevalence /1000**
Age	Young	0	61	61	0.0	0.0
	Middle	3	270	273	1.1	11.0
	Old	1	83	84	1.2	11.9
Sex	Males	3	349	352	0.9	8.5
	Females	1	44	45	2.2	22.2

Table 17: Frequency and Prevalence of Rib Lesions indicative of TB in the Adult Age and Sex-specific samples

Rib Lesions - TB		**Present**	**Absent**	**Number (*n*)**	**Frequency (%)**	**Prevalence /1000**
Age	Young	1	60	61	1.6	16.4
	Middle	2	249	251	0.8	8.0
	Old	1	75	76	1.3	13.2
Sex	Males	3	318	321	0.9	9.3
	Females	1	46	47	2.1	21.3

Treponemal Infections

Like tuberculosis, treponemal infections are among the most frequent infectious causes of death listed in the *Register of Burials at the Milwaukee County Poor Farm 1882-1925*. Syphilis is listed as the primary cause of death for fifty individuals (1.7%) out of a total of 2,891 individuals with associated causes of death. Among infectious causes of death, syphilis consists 4.8% of listed causes of death. Similarly, congenital syphilis is listed as the primary cause of death for 19 individuals (0.7%), all of which are subadults. As such, this study includes an examination of one individual with pathology suggestive of a treponemal infection. The individual represents possible evidence of acquired syphilis in the tertiary stage.

Burial 6254 is estimated as a young adult (20-34 years) male. The inventory for this individual includes the cranial vault, fragmentary ribs and vertebrae (including thoracic vertebrae), and all long bones. Evidence for extensive remodeling of the cranial vault is present. Uneven thickening of the diploic space and focal bone loss without penetration of the inner table can be seen in frontal, parietal, and occipital bones. The remodeling shows evidence of considerable healing with no active lesions typical of syphilis called caries sicca (Ortner 2003). Every long bone also shows evidence of periostitis. The bone formation is both sclerotic and woven with cortical thickening, in many cases there is evidence of endosteal bone formation that restricts the medullary cavity.

Degenerative Processes

As part of the analysis of indicators of health, the adult sample was examined for the most common evidence of degenerative processes, namely degenerative joint disease. This pathology, when present, is rarely related to associated causes of death. Instead it provides a measure of stress, particularly activity-based stress (Larsen 1997). A total of 462 individuals (92.4%) within the MCIG adult sample exhibit evidence of degenerative changes on the articular surfaces of the wrist, shoulder, elbow, hip, knee, and ankle. These changes included porosity on the articular surfaces, lipping of joint margins, bone loss, and in some cases eburnation. In addition, 408 individuals (81.6%) exhibit evidence of degeneration in the vertebrae. Degeneration of the vertebrae consists primarily of osteophytic lipping and depressions caused by pressure from the intervertebral disc, called Schmorl's nodes (*Standards* 1994). Three hundred and eighty-six adults (77.2%) showed evidence in both the joints and vertebrae. The following section looks more closely on the demographics of degenerative joint disease within the MCIG sample.

While examining the paleopathology associated with the sample used in this study, several adults were found with pathology that is suggestive of other degenerative processes. The first of these is Burial 9279. Burial 9279 is estimated as a young adult (20-34 years) male. Evidence of multifocal lytic lesions is present on the anterior and lateral aspects of all thoracic vertebral bodies. The lesions expose reactive bone formation, but show no evidence of vertebral collapse. Slight lytic activity is present of the anterior aspect of third through seventh cervical vertebral bodies. The erosive pathologies on the vertebrae exhibit "scalloping" (Ortner 2003) defects that are unlike those seen with infectious disease found in other individuals within the sample. The location along the anterior portion of the vertebral column and the nature of the defects is suggestive of an aneurysm of the descending thoracic aorta that could be arteriosclerotic in origin.

Burial 9242 is estimated as an old adult (50+ years) male. Evidence for an osteoblastic lesion is present of the left side of the mandible. The lesion, measuring 8 cm in length and 3.6 cm in width, encompasses the posterior mandibular body (including alveolar portions) and the ascending ramus. The bone formation appears active at the time of death. Possible causes of the lesion include a metastatic tumor due to carcinoma.

Age and Sex Differences among the Adults

For each indicator of health, the adult sample was examined for any observable differences based on age and/or sex cohorts. Tables 18 and 19 summarize the overall adult female and adult male samples respectively. Pearson's chi-square was used to test for significance at the $p < 0.05$ levels. For each indicator of health considered between the identified males and females, no pathology shows a significant result or an association between the variables considered when comparing the sexes. The following chi-square statistics were established: LEH ($\chi^2 = .565$, df=1); porotic hyperostosis involving the parietal ($\chi^2 = 2.482$, df=1); cribra orbitalia ($\chi^2 = 2.908$, df=1); periostitis involving the tibia ($\chi^2 = .197$, df=1); infectious disease ($\chi^2 = .022$, df=1); and evidence for degenerative joint disease (χ^2= 4.009, df=1). For all chi-square measures, Fisher's Exact test was used to examine significance when the expected count of any cells was less than 5. Figure 16 shows the frequency of each indictor of health for both adult males and adult females.

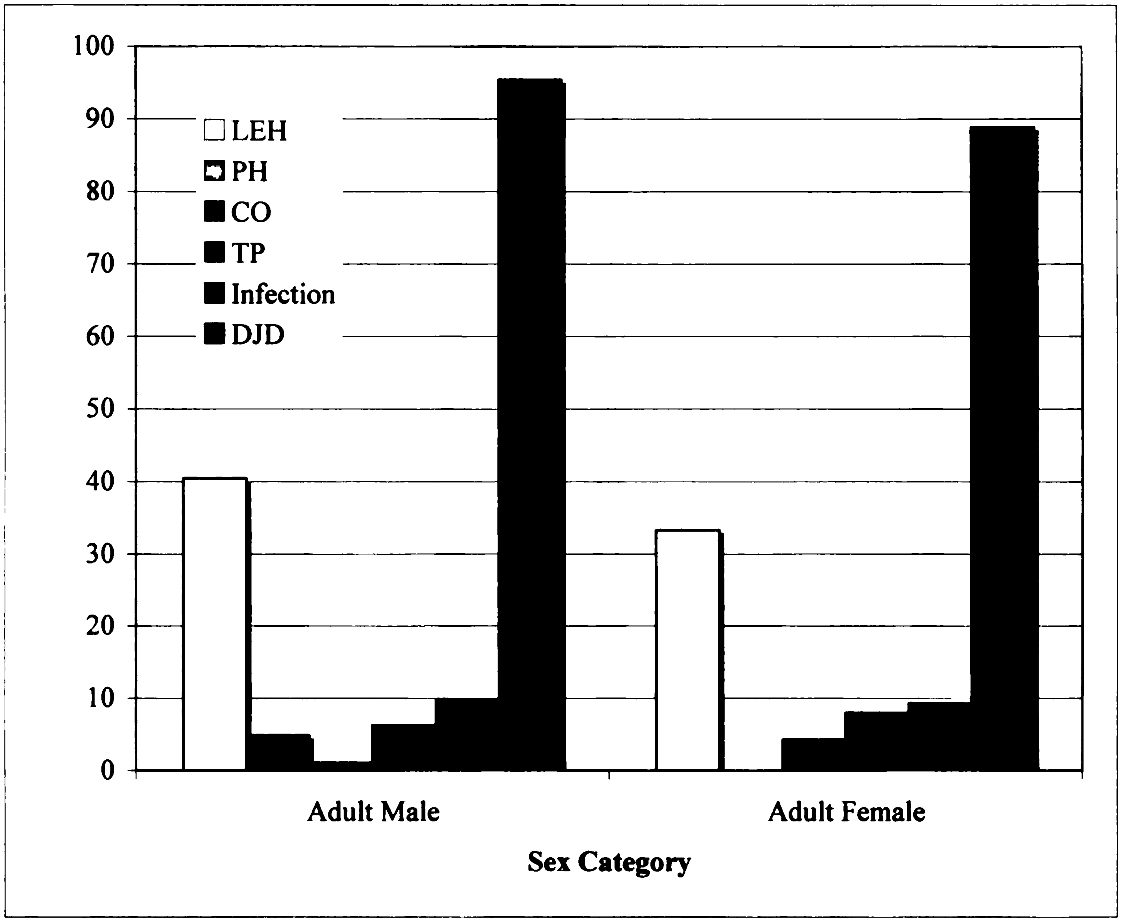
Table 18: Frequency and Prevalence Rates for the Adult Female Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	6	13	18	33.3	333.3
Porotic Hyperostosis - Parietal	0	48	48	0.0	0.0
Cribra Orbitalia	2	44	46	4.3	43.5
Periostitis – Tibia	4	46	50	8.0	80.0
Infectious Disease	5	49	54	9.3	92.6
DJD	48	6	54	88.9	888.9

Table 19: Frequency and Prevalence Rates for the Adult Male Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	66	97	163	40.5	404.9
Porotic Hyperostosis - Parietal	18	346	364	4.9	49.5
Cribra Orbitalia	4	354	358	1.1	11.2
Periostitis – Tibia	24	354	378	6.3	63.5
Infectious Disease	39	355	394	9.9	99.0
DJD	376	18	394	95.4	954.3

Figure 16: Frequency of each indicator[1] of health by adult sex



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (TP), Infection – nonspecific and specific, Degenerative joint disease (DJD)

The adult sample was also examined for age-related differences between those classified as young, middle-aged, and old adults. Tables 20, 21, and 22 show the frequency and prevalence rates of each indicator of health for the adult age categories. Pearson's chi-square was used to test for significance at the p <0.05 level. Three indicators of health show significant age differences: cribra orbitalia, infectious disease, and degenerative joint disease. The frequency of cribra orbitalia between young adults and middle-aged adults was significant with a chi-square statistic of $\chi^2 = 8.988$ with 1 degree of freedom. Cribra orbitalia was present in three young adults or 4.9% of the sub-sample as compared to one middle-aged adult or 0.4% of the sub-sample. There was no significant difference between either young adults and old adults or middle-aged adults and old adults.

The frequency of infectious disease between young adults and old adults was significant with a chi-square statistic of $\chi^2 = 3.859$ with 1 degree of freedom. Evidence for infectious disease is present in fourteen old adults or 15.2% of the sub-sample as compared to only four young adults or 5.5% of the sub-sample. Neither the young adults nor the old adults were found to be significantly difference than the middle-aged adults.

The frequency of degenerative joint disease shows the most variation between age categories. A significant chi-square statistic of $\chi^2 = 16.222$ with 1 degree of freedom was found between the young adults and the middle-aged adults. Fifty-nine young adults show evidence for DJD or 81.9% of the sub-sample as compared to two hundred and ninety-five middle-aged adults or 95.5% of the sub-sample. Likewise, a chi-square statistic of $\chi^2 = 10.041$ with 1 degree of freedom was found between the young adults and the old adults. Eighty-nine old adults or 96.7% of the group show evidence for DJD. No significant differences were found between the middle-aged and old adults.

The frequency of degenerative joint disease (DJD) between old adult females and old adult males was also found to be significant at the $p < 0.05$ level. The chi-square results show a statistic of $\chi^2 = 11.04$ with 1 degree of freedom. Seventy-six old adult males or 100% of the sub-sample exhibit evidence for degenerative processes as compared to twelve old adult females or 85.7% of the sub-sample. Figure 17 shows the frequency of each indicator of health for the adult age categories while Figure # shows the frequency of each indicator for age and sex-specific categories such as young males, middle-aged males, and old males. The percentage of each age and sex-specific group in the overall observation of each indictor is graphically shown in figure 18.

Table 20: Frequency and Prevalence Rates for Young Adult Sample

Pathology	**Present**	**Absent**	**Total Number**	**Frequency %**	**Prevalence /1000**
LEH	16	20	36	44.4	444.4
Porotic Hyperostosis - Parietal	4	57	61	6.6	65.6
Cribra Orbitalia	3	58	61	4.9	49.2
Periostitis – Tibia	3	62	65	4.6	46.2
Infectious Disease	4	68	72	5.5	55.5
DJD	59	13	72	81.9	819.4

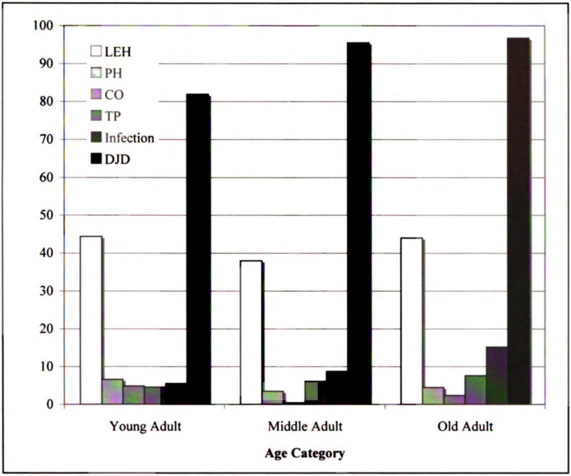
Table 21: Frequency and Prevalence Rates for Middle-aged Adult Sample

Pathology	**Present**	**Absent**	**Total Number**	**Frequency %**	**Prevalence /1000**
LEH	49	80	129	38.0	379.8
Porotic Hyperostosis - Parietal	10	275	285	3.5	35.1
Cribra Orbitalia	1	279	280	0.4	3.6
Periostitis – Tibia	18	278	296	6.1	60.8
Infectious Disease	27	282	309	8.7	87.4
DJD	295	14	309	95.5	954.7

Table 22: Frequency and Prevalence Rates for Old Adult Sample

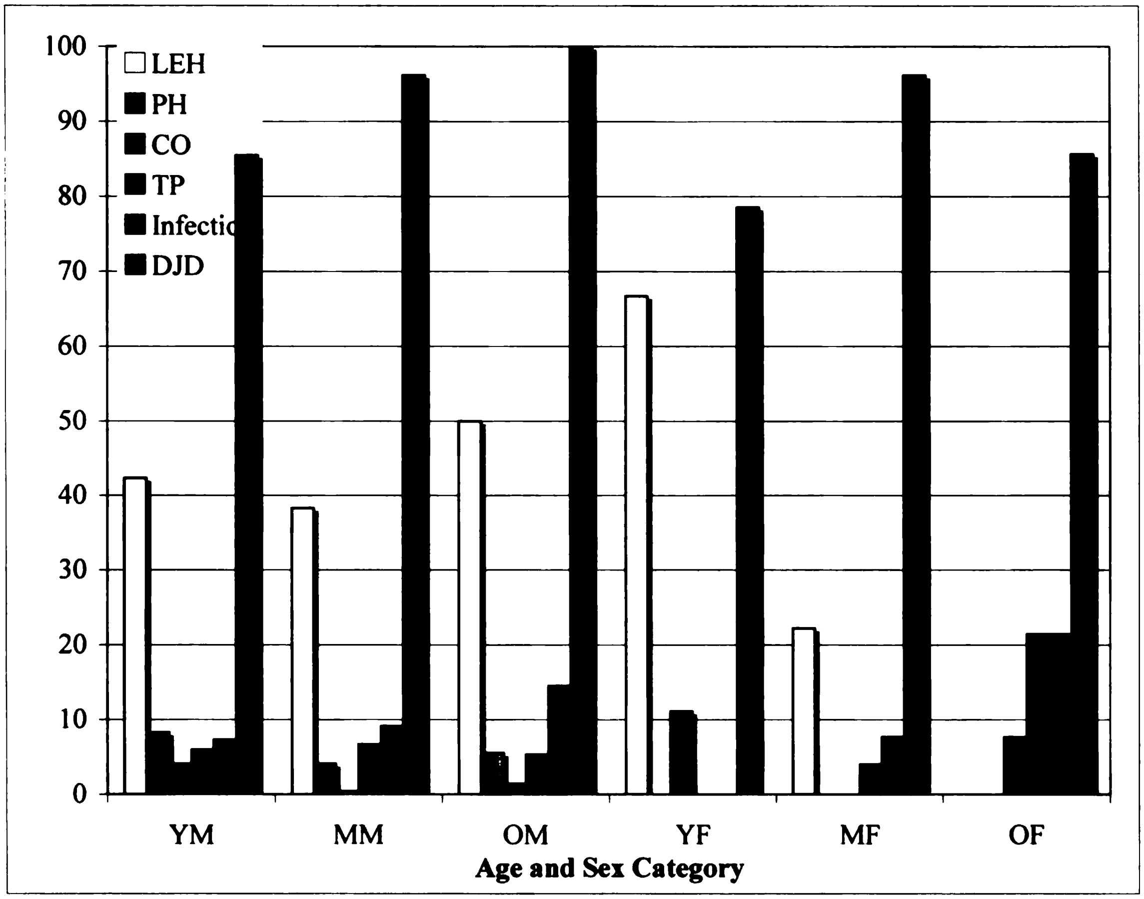
Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	11	14	25	44.0	440.0
Porotic Hyperostosis - Parietal	4	85	89	4.5	44.9
Cribra Orbitalia	2	83	85	2.4	23.5
Periostitis – Tibia	7	85	92	7.6	76.1
Infectious Disease	14	78	92	15.2	152.2
DJD	89	3	92	96.7	967.4

Figure 17: Frequency of each indicator[1] of health by adult age



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (TP), Infection – nonspecific and specific, Degenerative joint disease (DJD)

Figure 18: Frequency of each indicator of health for age and sex-specific[1] adults



[1] The adults are divided into the following categories: young male (YM), middle-aged male (MM), old male (OM), young female (YF), middle-aged female (MF), and old female (OF).

Age Differences among the Subadults

For each indicator of health, the subadult sample was examined for any observable age-related differences. Tables 23, 24, and 25 summarize the infant, child, and juvenile samples respectively. Pearson's chi-square was used to test for significance at the *p* <0.05 levels. Fisher's Exact test was used to examine significance when the expected count of any cells was less than 5.

Two indicators of health for the subadults show significant differences: linear enamel hypoplasias (LEH) and evidence for periostitis on the tibia. A significant chi-square statistic of χ^2=47.506 with 1 degree of freedom was found between the infant and child sub-samples in relation to the presence of LEHs. This indicator of health was present in twenty-one infants or 9.8% of the sub-sample as compared to twelve children or 70.6% of the sub-sample. In addition, a significant chi-square statistic of χ^2= 4.090 with 1 degree of freedom was found between the child and juvenile groups. One juvenile or 20.0% of the sub-sample shows evidence of LEHs. No significant differences were found between the infant and juvenile groups. Significant differences in periostitis were observed between the infant and child groups with a chi-square statistic of χ^2= 26.042 and 1 degree of freedom. One infant or 0.4% of the sub-sample shows evidence of this pathology as compared to two children or 15.4% of the sub-sample. The juvenile groups show no significant differences with either the infant or child groups. Figure 19 shows the frequency of each indictor for the subadult age categories.

Table 23: Frequency and Prevalence Rates for Infant Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	21	193	214	9.8	98.1
Porotic Hyperostosis - Parietal	10	78	88	11.4	113.6
Cribra Orbitalia	2	170	172	1.2	11.6
Periostitis - Tibia	1	263	264	0.4	3.8

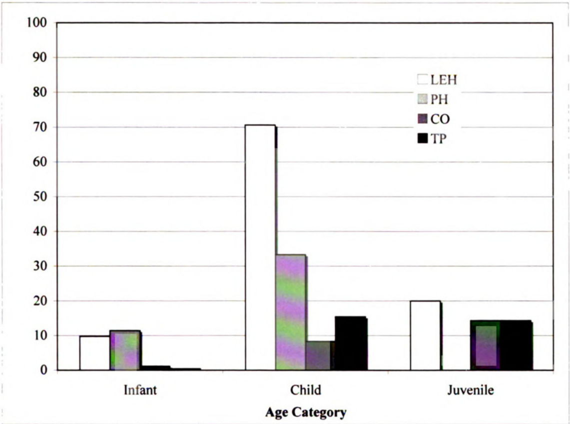
Table 24: Frequency and Prevalence Rates for Child Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	12	5	17	70.6	705.9
Porotic Hyperostosis - Parietal	2	4	6	33.3	333.3
Cribra Orbitalia	1	11	12	8.3	83.3
Periostitis - Tibia	2	11	13	15.4	153.8

Table 25: Frequency and Prevalence Rates for Juvenile Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	1	4	5	20.0	200.0
Porotic Hyperostosis - Parietal	0	5	5	0.0	0.0
Cribra Orbitalia	1	6	7	14.3	142.9
Periostitis - Tibia	1	6	7	14.3	142.9

Figure 19: Frequency of each indicator[1] of health by subadult age



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis on the tibia (TP)

Summary

This chapter looks at a number of indicators of health for the skeletal remains associated with the Milwaukee County Institution Grounds cemetery. Overall, the sample shows evidence for nutritional, developmental, disease, and activity-based stress. When looking specifically at the adults, linear enamel hypoplasias, tibial periostitis, and degenerative joint disease are the most frequent indicators. These indicators suggest that early developmental stress, infection, and degenerative changes show the most evidence for impacting the adults interred on county grounds. While the adult sample also shows evidence for porotic hyperostosis and cribra orbitalia, these two indicators have comparably lower prevalence rates within the sample. Porotic hyperostosis and cribra orbitalia are generally assumed to provide information on nutritional deficiencies within a skeletal sample. The relation between these deficiencies and disease is explored further in Chapter 7, the final chapter of this dissertation.

Among the subadult sample, linear enamel hypoplasias and porotic hyperostosis show the highest prevalence among the indicators of health examined for the sample. The presence of both nutritional and developmental stress among the subadult remains provides valuable insight into the types of stressors that may have been present around the time of death for these individuals. Overall, the subadult sample shows the lowest prevalence rates for tibial periostitis, a non-specific indicator of infection. Given the high percentage of the subadult sample aged at less than one year, the low prevalence for skeletal indicators related to infection is expected, as this age group would have been more susceptible to acute infections.

This chapter also includes an analysis of the differences that are present between the age and sex-specific subgroups within the sample. Looking first at the adults, the comparative analysis of males and females within the sample was unexpected. In particular, the results of the skeletal analysis for the MCIG cemetery showed little sex related differences between the adults interred in the cemetery. The differences that are observed were not found to be significant. The expectation for the comparison of males and females in the MCIG sample was that there would be significant differences found between the groups with adult males showing a higher prevalence for several indicators of health. This expectation was based on the demographic composition of the sample, as adult males comprise over three-quarters of the total adult sample. Social welfare programs aimed at women and children in the city of Milwaukee were also expected to impact the health observed for the adult female sample.

In contrast, the adult sample did show several age-related differences. Cribra orbitalia, evidence for infection, and degenerative joint disease are the indicators that showed significant differences. The most apparent differences are between the young adults and both the middle-aged and older adults. The young adults exhibit comparably higher levels of cribra orbitalia and less evidence for infection and degenerative processes than the middle-aged and old adults. Within the subadult sample, differences between the infant (less than 1 year of age) and child (1-4.9 years) groups are most pronounced. Linear enamel hypoplasias and nonspecific infections, measured by the presence of periostitis on the tibia, are the two indicators found to be significant with both being more frequently found in the child age category. The juvenile age group also exhibits a significant difference from the high level of LEHs found among the child group.

The next chapter, chapter 6, will look at how those interred in the MCIG cemetery compare to similar skeletal samples. Chapter 7 looks more closely at the MCIG sample and the results found between the subgroups within the skeletal sample, particularly in relation to the results from the comparative analysis. A discussion of the relative health of the MCIG sample is included in the final chapter as well.

Chapter 6 – Comparative Studies

Introduction

The previous chapter outlined the results of an analysis of health for the Milwaukee County Institutional Grounds Cemetery. In particular, it highlighted information on paleopathological conditions often used to assess the relative health of a sample. However, taken alone, the results lack the contextual background to assign a value to the observed health. The following chapter looks more closely at place of the MCIG sample among similar skeletal samples, representing time periods directly preceding that covered by the MCIG cemetery #2. However, the chapter starts with a comparative analysis of the historical documentation associated with both the cemetery and the City of Milwaukee in order to look more closely at the historical trends affecting the presence or absence of pathology in the MCIG skeletal sample.

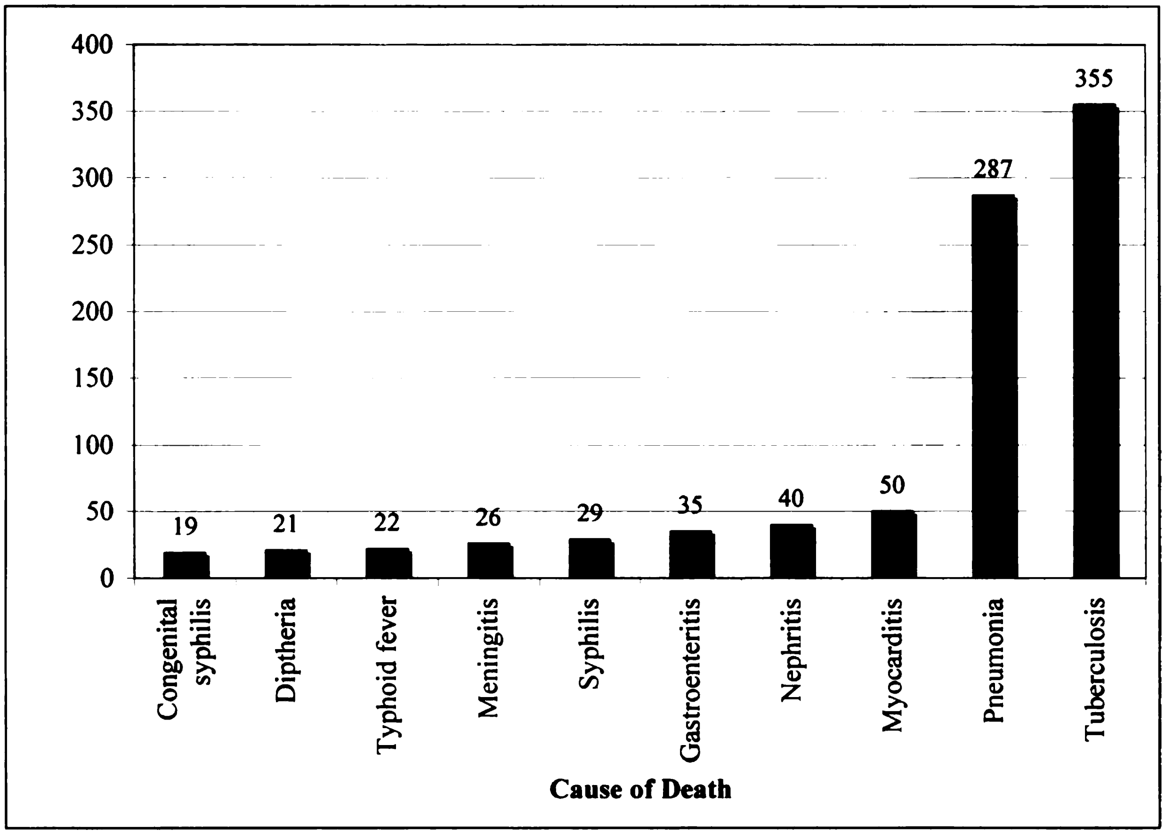
Comparisons with Historical Records

Infectious Disease

The observed presence of infectious disease within the skeletal sample was compared with the observed causes of death listed in the burial registry. Causes of death, listed in both the G.L.A.R.C. Reports of Investigation (1993) and the Register of Burial 1882-1925, provide information as to the specific pathological conditions affecting the individuals interred on the Milwaukee County Grounds. Of a total of 5,288 individuals listed in the Register, 2,891 individuals had associated causes of death. The inclusion of cause of death information in the Register of Burial was inconsistent prior to 1908. After 1908, every burial entered into the Register between the years 1908-1925 has associated cause of death information. Furthermore, of the 2,891 individuals with noted causes of death, 1,031 individuals (35.7%) have a cause of death that could be contributed to infectious disease.

A list of the ten leading infectious diseases utilized as a data set for the study can be found in Figure 20. These diseases include the most common infectious processes that affect the skeleton, namely tuberculosis and syphilis. Also included is pneumonia, which despite being more commonly defined as an acute disease still holds the potential for eliciting bony responses to pathogens. Leavitt (1982) also notes that these acute pathologies often masked true pathologies such as tuberculosis.

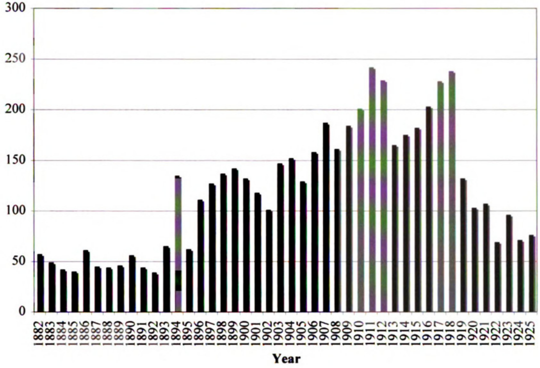
Figure 20: Number of Individuals listed with an Infectious Cause of Death[1]
Source data: *Register of Burial at Milwaukee County Poor Farm 1882-1925*



[1] The graph depicts the top 10 infectious causes of death: congenital syphilis, diphtheria, typhoid fever, meningitis, acquired syphilis, gastroenteritis, nephritis, myocarditis, pneumonia, and tuberculosis

Figure 21 shows the number of burials at the Milwaukee County Grounds Cemetery for each year between 1882 and 1925. The bars highlighted in grey single out years with sudden increases in the number of burials. They reflect several of the major epidemics to impact the city of Milwaukee: the 1894 smallpox epidemic; the 1910-1912 typhoid epidemic; and the 1918 Influenza epidemic.

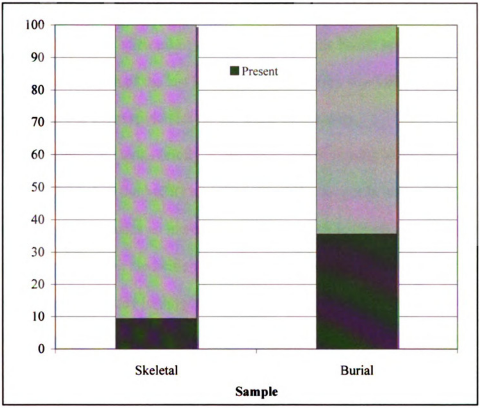
Figure 21: The Number of Burials between 1882-1925 interred at the MCIG cemetery
Source data: *Register of Burial at Milwaukee County Poor Farm 1882-1925*



Given the impact of infectious disease seen in the burial registry for the MCIG cemetery, a comparison between the reported infectious causes of death in the registry and the presence of non-traumatic infection in the skeletal sample was included in the comparative analysis. Infection in the MCIG skeletal sample was counted when the bony reaction was not localized and not obviously associated with trauma. One of the characteristic features of infectious disease in the skeleton is the involvement of several, specific skeletal elements (Ortner 2003). As such, individuals who exhibited systemic responses to infection or reactions that affected common skeletal sites of infection (i.e. the tibiae) were selected for consideration.

The frequency of individuals exhibiting systemic infection was compared to the frequency of individuals listed in the burial registry with an infectious cause of death. The McNemar test for related samples was used to test for significance, as the individuals included in the skeletal sample are the same individuals listed in the burial registry. The resulting chi-square statistic (χ^2= 224.346, df=1) was significant at the p <.01 levels. The presence of skeletal infection underestimates the total number of individuals affected by infection at the time of death. Figure 22 shows the percentage of both the skeletal sample and the burial registry sample affected by infectious disease.

Figure 22: Percentage of the Skeletal and Burial Record Samples affected by Infectious Disease



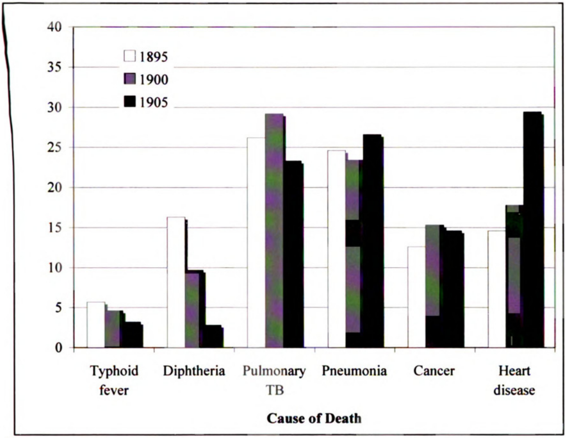
Degenerative Processes

One of the expectations posed in Chapter 2 was that the MCIG sample would show evidence for a decreasing mortality rate from infectious disease and a corresponding increase in degenerative processes. As stated previously, while the measures of infection in a skeletal sample relate directly to infectious causes of death, the evidence for degenerative processes in skeletal samples often reflect morbidity and not mortality. Skeletal degeneration includes those changes that result from largely activity-based stressors. It rarely reflects degenerative diseases as listed in the registry of burial.

As such, the comparative analysis for degenerative processes looks at the historical sources for the MCIG cemetery and the City of Milwaukee. In particular, the annual reports from Milwaukee's Heath Department and the Register of Burial for the MCIG cemetery were examined. Both sources provide yearly information on causes of death. Chapter 2 outlines Milwaukee's struggle with public health reform and control of periodic epidemics. Much of the last half of the 19th century was influenced by the substantial impact of these epidemics on the larger community.

The current study looks briefly at the timeframe beginning at the start of the 20th century and ending when the MCIG cemetery #2 was no longer in active use. The intervening 25 years includes an increasingly effective public health movement and corresponding advances in medicine's contribution to the control of infectious pathogens. Six diseases in particular are highlighted in the following figures: typhoid fever; diphtheria; tuberculosis; pneumonia; cancer; and heart disease. These diseases are all listed as leading causes of death in the City of Milwaukee. Figure 23 shows the frequency of each of these diseases at 5-year intervals starting in 1895 and ending in 1905 from the Milwaukee Health Department annual report for 1907. Declines in the frequency of typhoid fever and diphtheria can be seen. In contrast, the frequency of cancer and heart disease (degenerative diseases) shows a general increase during the years considered. Although a slight decrease in the frequency of tuberculosis is seen, available historical information highlights the relatively stable impact that both tuberculosis and pneumonia had on the mortality rates for the City of Milwaukee. The city's efforts towards combating tuberculosis in particular were minimal prior to 1912, when the health department added a division for tuberculosis to its daily operations (*MHD 1912*).

Figure 23: Changes in Frequency[1] for 6 Major Causes of Death within the City of Milwaukee 1895-1905 Source: *MHD 1907*

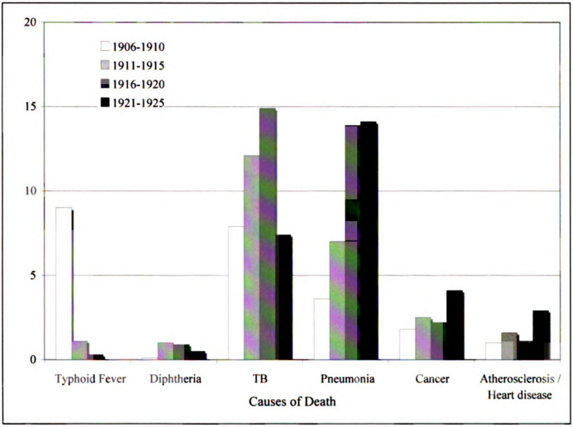


[1] Frequency is determined by the number of deaths for each cause of death divided by the total number of deaths attributed to these six causes in the years 1895, 1900, and 1905

Figure 24 shows the trends in causes of death as listed in the burial registry for the MCIG cemetery. The frequency of the causes of death shown in the graph are derived from the timeframe for which cause of death information was available in the registry and is grouped by 5-year intervals. Like the trend seen between 1895 and 1905 in the health department report, the burial registry reflects a decreasing frequency of typhoid fever and diphtheria between 1906 and 1925. The registry also supports the general increase in the frequency of cancer and heart disease. While the frequency of tuberculosis and pneumonia remains high, a noticeable decrease in tuberculosis can be seen during the

1921-1925 period. As a note, the high number of causes of death attributed to tuberculosis and pneumonia in the 1916-1920 period and the slight drop in cancer and heart disease for the same period reflects the large number of deaths from acute inflections during the 1918 Influenza epidemic. Figure 25 shows a portion of the burial record for the fall of 1918.

Figure 24: Changes in Frequency[1] for 6 Major Causes of Death listed in the MCIG Burial Registry, source: *Register of Burial at Milwaukee County Poor Farm 1882-1925*



[1] Frequency is determined by the number of deaths listed for each cause of death divided by the total number of burials interred on county grounds between the shown timeframes

Figure 25: Cause of Death as listed for 1918 "Influenza Pneumonia", source: *Register of Burial at Milwaukee County Poor Farm 1882-1925*

Temporal Trends in the MCIG Sample

Introduction

The *Reports of Investigation No. 333* (Richards and Kastell 1993) details efforts during the original excavation to date sections of the cemetery based on artifactual evidence. The excavated sections of the cemetery were divided into Areas A-N and were arbitrary depending on construction schedules (Richards and Kastell 1993). Each area was assigned separate burial lot numbers. As stated in Chapter 3, Areas B, C, D, H, J, K, L, and N yielded burials with individual remains. Table 26 shows each area and the associated burial lot numbers.

Table 26: Excavated Areas and associated Burial Lot Numbers

Excavated Area	Burial Lot Numbers
B	1000-1053
C	2000-2160
D	3022, 3028-3075
H	5000-5259
J	6000-6295
K	7000-7264
L	8001-8202
N	9001-9475

The original areas of the cemetery are labeled Areas I-VII and are based on the reconstructed spatial organization determined during the archaeological excavations. The reconstruction is based on both archaeological evidence such as post molds and the arrangement of graves, as well as, historical evidence from early maps and the burial registry (Richards 1997). The presence of artifactual evidence, such as burial tags, helps confirm a land use timeline for limited areas within the cemetery. Table 27 shows the original areas with their associated timelines. Areas highlighted in grey have confirmed timelines associated with them, while the timeline for those in white is estimated.

Table 27: Original Areas and associated Timeline

Original Areas	Land Use Timeline
I	early 1880s - <1905
II	>1915 - < 1925
III	>1915 - < 1925
IV	> 1900 - < 1925
V	> 1900 - < 1925
VI	>1920 - < 1925
VII	> 1920 - < 1925

For this dissertation, the areas of particular interest are those that hold adult burials. The burial registry shows that subadult burials were not given separate series for burial numbers until 1920 (*Register of Burial 1882-1925*). In addition, most of the subadult remains were recovered from areas that held exclusively subadult burials. It is assumed that the use of separate burial number series for the subadults would coincide with distinct areas for the burial of subadults within the larger cemetery. As such, while some of the subadults may represent an early timeframe, the estimated timeline for the subadults in the MCIG sample is for the period after 1900. The separation of subadults within the cemetery grounds without a separation in the series numbers between adults and subadults is possible, however, there is no direct evidence of this in the excavated areas. As a result, the subadults could not be separated into distinct temporal groups.

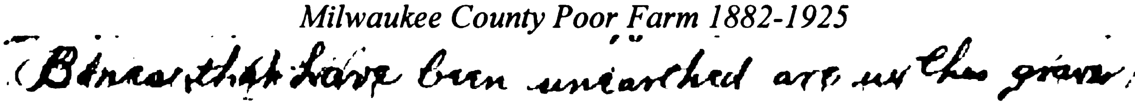
Table 28 shows the association between the excavated areas, burial lot numbers, and the original areas of the cemetery. An analysis of temporal trends within the adult burials utilized this information to attempt to create comparative groups.

Table 28: Excavated Areas and Burial Lot Numbers with associated Original Areas

Excavated Area	Burial Lot Numbers	Original Areas
B	1000-1053	I
C	2000-2160	I
D	3022, 3028-3075	II
H	5000-5259	I, II
J	6000-6295	V, VI, VII
K	7000-7264	I, III, VII
L	8001-8202	I, III, VII
N	9001-9475	I, II (NE corner)

Two groups were looked at for comparisons, those that could be tied to an earlier timeframe and those that represented a later timeframe. The earlier group is comprised of individuals from excavated areas B and C (burial lot numbers 1000-1053 and 2000-2160). Specifically, these areas include burial plots that were reused during the time the cemetery was in operation (Richards 1997). The burial registry notes that some of the later graves include bones from earlier burials that were disturbed when the same grave shaft was used. A portion of these notes (shown in Figure 26) mention that disturbed bones were thrown in when the grave was filled. These notes appear in the registry as early as 1910. As such, individual remains that could be tied to the earliest burial within a pit were presumed to represent an earlier time period.

Figure 26: "Bones that have been unearthed are in this grave", *Register of Burial at Milwaukee County Poor Farm 1882-1925*


(Bones that have been unearthed are in this grave)

The later group consists of individuals from excavated areas D, H, and N (burial lot numbers 3022, 3028-3075, 5000-5259, and 9001-9475). Individuals from these burial lot series that could be linked to original area II. Burial tags found in area II, dating between August 1918 and August 1922, confirmed a timeframe between 1915 and 1925 (Richards 1997).

Results

When looking at the skeletal remains, the current study was not able to distinctly separate adult individuals by time period for comparative purposes. The individuals included in the sample used from the MCIG cemetery provided very limited evidence of paleopathology due to the fragmentary nature of many of the remains, particularly those from the estimated early section of the cemetery. In addition, ambiguity in the link between the individuals excavated and the sections of the original cemetery represented by these excavations did not provide a context for a comfortable distinction between the sections of the cemetery with associated timelines.

Linking Names with Burials

A preliminary study was conducted in 2006 to test whether a portion of Area II could be linked to the names of individuals listed in the burial registry. This study, presented at the 2006 Midwest Bioarchaeology and Forensic Anthropology Association Conference by Devitt, Milligan and Sullivan, built upon the work done by Richards and Kastell (1993) and Richards (1997). As discussed previously, several burial tags were recovered in Area II of the MCIG cemetery. These tags, along with other recovered personal effects, were used to identify individuals listed in the burial registry. An analysis of the distribution and orientation of graves was used to systemically link the order of the names in the registry with the order of the graves. For example, a burial row that contained a recovered tag would provide a starting point in the registry from which subsequent names listed in the registry would be assigned to each consecutive grave.

The opportunity to study known individuals within any burial context is a valuable resource for anthropologists. Devitt, Milligan, and Sullivan (2006) looked at several case examples where the combination of archival data and skeletal analysis were examined in relation to the archaeological work. Four individuals selected for comparison with the skeletal investigation done by Dr. Norman Sullivan at Marquette University and documents from the Milwaukee Historic Society are reported below. The initial skeletal analysis included inventory, age, sex, and paleopathology. The registry provides several important pieces of information such as place of death, including whether or not the body was transported to the morgue. For those individuals that were transported to the morgue, the coroner reports found at the Milwaukee Historic Society could be used to compare the pathologists' findings with the results of the skeletal analysis.

Burial 5150

Richards and Kastell (1993) and Richards (1997) identified Burial 5150 as "Ernest Gutschke". The coroner's report for Ernest Gutschke (located at the Milwaukee Historical Society) listed the individual as an adult male with estimated age of 45 years. The cause of death was given as a skull fracture with severe intracranial hemorrhaging. An operating wound on the left temporal bone is also noted. Autopsy notes are included in the coroner's report. The examination of the skeletal remains scored the individual as an adult male with an associated age of 40-55 years of age. Cranial evidence of an autopsy was present in addition to evidence of a trephination on the left temporal bone.

Burial 5108

Burial 5108 is identified as "Unknown Man #187" (Richards and Kastell 1993; Richards 1997). The coroner's report filed for Unknown Man #187 listed the individual as an adult male with an estimated age at death of 45 years. The cause of death is listed as accident by railroad with the autopsy report including multiple fractures of the upper and lower limbs, pelvis, and ribs. Autopsy notes are included in the coroner's report. The skeletal analysis scored the individual as an adult male with an estimated age of 35-50 years. Observed skeletal trauma included multiple fractures of the right tibia, right fibula, left femur, left ulna, and left radius. Evidence for an autopsy was also present. No trauma was noted for the pelvis or ribs due to preservation.

Burials 5145 and 5146

Burials 5145 and 5146 were both named as the possible burials for "John Robinson" (Richards and Kastell 1993; Richards 1997). The coroner's report for John Robinson listed the individual as an adult male with an estimated age at death of 40 years. The cause of death is listed as a gunshot wound to the abdomen. Autopsy notes are included in the coroner's report. The skeletal analysis for Burial 5145 scores the individuals as an adult male with an estimated age of 20-35 years. Burial 5146 is scored as an adult male with an estimated age of 30-45 years. Neither burial showed evidence for skeletal trauma or cranial evidence for an autopsy.

Discussion

Devitt, Milligan, and Sullivan (2006) note that, while burials 5150 and 5108 provide strong skeletal evidence of a possible match with individuals identified in the burial registry, burials 5145 and 5146 do not. The exclusion of these latter two burials as possible matches for "John Robinson" suggests that further research is needed to assess how many excavated individuals from Area II can be correctly linked with the associated burial registry for the MCIG cemetery.

Reports by Richards and Kastell (1993) and Richards (1997) were limited to the archaeological analysis and did not have available the accompanying skeletal analysis. As presented here, the combination of the archaeological reports and the skeletal investigation sheds light on possible inconsistencies in either the burial of individuals on county grounds or how accurately individuals were recorded in the burial registry. The original interments may have encroached upon older burial plots already in use on the county grounds or included individuals who were buried without being properly marked in the burial registry. Other later disturbances to the interments may also account for the inconsistencies seen between the excavated remains and the associated historical documentation. Regardless, a larger study of the burials included in Area II is needed.

Comparisons with Other Skeletal Samples

As briefly introduced in Chapter 4, the comparative analysis for this dissertation includes a look at the presence and absence of several indicators of health in other skeletal samples. Each sample selected is compared separately to the MCIG sample, although a discussion of the trends seen between all samples is included in the concluding chapter of this study. The Milwaukee County Indigent Grounds was used by

Milwaukee's various institutions, but they were also used as burial grounds for the unidentified dead from the city proper and for those individuals unable to afford burial fees. As such, the burial sample collected from the county grounds represents an admixture from several different populations within the greater Milwaukee area. This is evidenced by the differences in demographics seen between the MCIG sample and Dunning and Monroe County Poorhouse sample. Both samples are comprised of burials exclusively from Chicago and Rochester's institutions.

The age categories established for each sample are: infant (< 1 year); child (1-4.9 years); juvenile (5-19.9 years); young adult (20-34.9 years); middle-aged adult (35-49.9 years); and old adult (> 50 years). In general, the age and sex data collected for all samples was similar and the demographics for each could be established using the MCIG categories as the base. When an assigned age was unclear or crossed the line between two age categories in Dunning, Monroe County, or Voegtly, the median age was considered for the range provided by the original authors. For example, in the Dunning sample, an assigned age range of 15-21 years was categorized as a juvenile as the median age is 18. An age range of 15-29 years was categorized as a young adult in the Monroe County sample as the median age is 22.

The Voegtly skeletal sample showed the most variation in reported age ranges. An age range of 30-40 with a median age of 35 in the Voegtly sample was categorized as a middle-aged adult. Out of a reported 544 individuals with associated age, 512 were used for the current study. As the comparisons with the MCIG sample are based primarily on differences seen in age and/or sex cohorts within each sample, individuals with very poor preservation were excluded. For example, a fragmentary individual with unknown sex and an age range of 20-80 years was not considered. For all samples, Table 29 and 30 show the number and frequency of individuals for both the subadult age categories and the adult age and sex categories respectively. The age cohort with the highest frequency of individuals within each sample is highlighted for both the subadult and adult tables. The demographics for each sample listed in the tables are used for the skeletal comparisons with the MCIG sample.

The MCIG sample has significantly more infant remains (< 1 year) and remains classified as middle-aged males (35-49.9 years). The higher numbers seen in the MCIG sample, particularly in these categories, can be associated with the inclusion of individuals from the city proper. The large immigrant population in the city included a large number of unmarried adult males working at industrial jobs. In addition, the burial registry for MCIG shows that a significant number of stillborn infants were sent to the county grounds for burial. Richards (1997) reports that the median age at death for those from the city proper listed in the cemetery burial registry was 32 years of age. In contrast, the adult population at Milwaukee's institutions shows a median age of 47.50 years (Richards 1997).

With both the Dunning Poorhouse and the Monroe County Poorhouse subadult samples, the age category to show the highest frequency is the child group (1-4.9 year of age). Most likely, this reflects young children accompanying their mothers (or parents) in the poorhouse or indigent or orphaned children cared for at the institutions. An article by Grauer and McNamara (1995) states that differences in subadult age structure between Dunning and Monroe County were not statistically significant. Dunning shows the highest frequency for young adults (20-34.9 years) in both its adult male and adult female categories. This trend mirrors reports from historical sources which list young adults as the largest group admitted to the poorhouse (Grauer *et al.* 1998). Monroe County also shows a high frequency of young females in their adult sample, but has a higher frequency of old adult males (> 50 years) than either young or middle-age males. The study of the Monroe County Poorhouse cemetery by Lanphear (1988) does not discuss the reasons for a higher frequency of old adult males. However, a later study by Sirianni (1999) mentions that cholera epidemics were common during the time the cemetery was in operation, a disease which puts middle-aged and older adults more at risk.

The infant group and the young adult males and females show the highest frequencies in the Voegtly Cemetery subadult and adult samples. During the original study, the associated Voegtly Church cemetery records were used in the demographic analysis of the remains (Ubelaker and Jones 2003). The records show that the majority of those buried in the cemetery were under the age of 20. The authors report that this trend fits the immigration pattern for the Voegtly community, where families would have emigrated together (Ubelaker and Jones 2003). Life tables generated in the study show peak mortality for both males and females was between 25-35 years of age.

One common trend between the MCIG, Dunning, and Monroe County samples is that the majority of individuals buried in the cemeteries are adults. Ubelaker and Jones (2003) mention, in their comparisons with the Dunning and Monroe County samples, that the Voegtly cemetery shows the opposite trend. More subadults were interred in the cemetery than adults. This, in part, reflects the difference between institutional-based cemeteries and community-based cemeteries.

Table 29: Number and Frequency of Individuals in Subadult Age Categories

Cemetery	MCIG	%	Dunning[1]	%	MonCo[2]	%	Voegtly[3]	%
Infant	346	*92.8*	13	*27.1*	20	*24.7*	173	*48.1*
Child	20	*5.4*	18	*37.5*	37	*45.7*	125	*34.7*
Juvenile	7	*1.9*	17	*35.4*	24	*29.6*	62	*17.2*
Total	373	*100.0*	48	*100.0*	81	*100.0*	360	*100.0*

1 Dunning Database and original data collection Sheets courtesy of Anne Grauer

2 Lanphear 1988

3 *Human Remains from Voegtly Cemetery* 2003

Table 30: Number and Frequency of Individuals in Adult Age and Sex Categories

Cemetery	MCIG	%	Dunning[1]	%	MonCo[2]	%	Voegtly[3]	%
Young Males	56	*11.4*	18	*31.0*	26	*15.2*	41	*27.0*
Middle Males	271	*55.2*	8	*13.8*	29	*17.0*	34	*22.4*
Old Males	78	*15.9*	1	*1.7*	57	*33.3*	15	*9.9*
Young Females	14	*2.9*	16	*27.6*	26	*15.2*	30	*19.7*
Middle Females	28	*5.7*	11	*19.0*	17	*9.9*	19	*12.5*
Old Females	15	*3.1*	1	*1.7*	16	*9.4*	10	*6.6*
Young Unknown	4	*0.8*	3	*5.2*	0	*0.0*	2	*1.3*
Middle Unknown	22	*4.5*	0	*0.0*	0	*0.0*	1	*1.0*
Old Unknown	3	*0.6*	0	*0.0*	0	*0.0*	0	*0.0*
Total	491	*100.0*	58	*100.0*	171	*100.0*	152	*100.0*

1 Dunning Database and original data collection Sheets courtesy of Anne Grauer

2 Lanphear 1988

3 *Human Remains from Voegtly Cemetery* 2003

Each of the samples used for comparative purposes required a slightly different approach in order to facilitate a comparative discussion. While each sample had associated data on the indicators of health selected for this study, the manner in which they were collected and presented varied between each. For example, the first comparative sample to be discussed is the Dunning Poorhouse Cemetery. The comparison of the Dunning data with the MCIG data was aided by access to the original raw data for the Dunning study, courtesy of Dr. Anne Grauer. The scoring system used to categorize that data utilized the field's best practices and was detailed on all data collection sheets. However, at the time that the data was collected, *Standards* (1994) had not yet been published so while similar, the data is scored slightly different than the MCIG sample. Similarly, the Monroe County data is also categorized by a system created by the author of the original study in 1988. The Monroe County data used for the present study is primarily based on the dissertation of Lanphear (1988). More recent studies of the Monroe County/Highland Park sample have been conducted and will be discussed briefly, however, the dissertation results provided the most complete inventory and report of pathology for the sample. Data for the last comparative sample, Voegtly cemetery, was derived from the report published by the Smithsonian Institution Press. Like the MCIG sample, the study of the Voegtly remains used *Standards* (1994).

For each sample, the results are presented by overall adult and subadult comparisons. Differences seen in subgroups based on age or sex (for example, adult males versus adult females) are also reported. These comparisons relied on the individuals in each sample for which an age and/or sex estimation was provided. The following sections look at the comparative results from each sample separately.

Dunning Poorhouse Cemetery

The Dunning Poorhouse Cemetery was originally established to accompany the Cook County Poor Farm, which included both an almshouse and an asylum (Grauer *et al.* 1998; Grauer and McNamara 1995). Located on the west side of Chicago, the cemetery was in use from 1851-1869. After 1869, the city removed and reburied most of the original cemetery in a new nearby cemetery (Grauer and McNamara 1995). Excavations completed in 1990 exhumed a total of 120 individuals from the old cemetery (Grauer *et al.* 1998).

As reported by Grauer *et al.* (1998), historical evidence from the time period during which the cemetery was in operation is limited. In particular, a newspaper account from 1854 describes the medical care as provided by a city physician, regular meals for the residents, and separate housing by age and sex. In contrast, an 1870 report by the Board of State Commissioners of Public Charities of the State of Illinois describes poor management and problems with overcrowding at the facilities (Grauer *et al.* 1998). The authors of the original study postulate that the lack of information regarding the early years of the Dunning Poorhouse might be due to the Chicago Fire of 1871, during which numerous city documents were lost (Grauer and McNamara 1995).

As stated in the previous section, compilation of the demographics and paleopathological analysis of the study were aided by access to the original databases for the Dunning sample, courtesy of the principal investigator of the original study, Dr. Anne Grauer. The availability of the raw data from the Dunning sample offered the greatest degree of flexibility in organizing comparative data among the samples used in this study. The presence or absence of four indicators of health was used for comparison of the subadults: linear enamel hypoplasias found in anterior teeth; porotic hyperostosis in the parietals; cribra orbitalia; and periostitis observed on the tibiae. For the adults, observations of degenerative joint disease (DJD) were included in addition to the four indicators mentioned above. Any available evidence for specific diseases such as tuberculosis was examined for both subadults and adults in the samples. All indicators of health are scored by individual.

Linear enamel hypoplasias observed on anterior teeth were included in the study. The frequency of this indicator of health was determined by the number of individuals with at least two observable, fully erupted anterior teeth. Porotic hyperostosis in the parietals was considered for those individuals with at least one parietal present. Frequencies of cribra orbitalia were calculated from the number of individuals with a frontal bone present and for which an inventory score of "13" or "no orbits" was not listed in the Dunning skeletal database. Periosteal bone reactions in individuals with at least one observable tibia were counted when no notes of a traumatic origin were present. The frequency of this indicator was determined by the number of individuals with an observable tibia for which an inventory score indicated that a portion or all of the shaft was present. The frequency of DJD for the adult sample was determined by the number of individuals exhibiting degenerative changes to the following joints: shoulder, elbow, wrist, hand, hip, knee, ankle, and foot. This indictor of health was counted for all adults for whom age and/or sex could be assigned. Evidence for specific diseases relied on the notes from the original study that indicated when observed paleopathology might be indicative of a specific disease.

Age and Sex Differences among the Adults from the MCIG and Dunning Poorhouse Cemeteries

The first comparison between the MCIG and Dunning samples looks at the adult samples used for this study. Tables 31 and 32 summarize the overall frequency and prevalence rates for the MCIG adult and Dunning adult samples respectively. The tables for the MCIG cemetery, shown in the previous chapter, are repeated with the Dunning results to provide a more direct visual comparison of the data. The adult tables for MCIG include all of the indicators of health used for the comparative analysis. However, not all indicators are used with each comparable sample. For both the Monroe County Poorhouse Cemetery and the Voegtly Cemetery sections, the tables included are those that pertain to the comparative sample only.

Pearson's chi-square was used to test for significance at the $p < 0.05$ levels. The presence of linear enamel hypoplasias, porotic hyperostosis, cribra orbitalia, and degenerative joint disease were found to be significant for the overall adult samples. For these indicators of health, the prevalence rate for linear enamel hypoplasias, porotic hyperostosis, and cribra orbitalia was higher in the Dunning adult sample than in the MCIG adult sample. Conversely, the MCIG adult sample showed a higher prevalence for DJD. Although the prevalence rate for periostitis was also found to be higher in the Dunning sample, it was the only non-significant comparison. For each of these indicators, the following chi-square statistics were established: LEH ($\chi^2 = 13.277$, df=1); porotic hyperostosis involving the parietal ($\chi^2 = 17.359$, df=1); cribra orbitalia ($\chi^2 = 46.031$, df=1); tibial periostitis ($\chi^2 = 3.323$, df=1); and evidence for degenerative joint disease

(χ^2= 49.823, df=1). Figure 27 shows the frequency of each indictor of health for both adult samples.

For all chi-square measures used in the comparative analysis, Fisher's Exact test was used to examine significance when the expected count of any cells was less than 5. As a note, the chi-square calculations involved weighting the frequency variable to look at the joint frequency distribution among both the indicators of health and the cohorts used for comparisons (such as age and sex groups). As such, when observations of an indicator of health for any subgroup contained a zero value, either no individuals showing the presence for or the absence of an indicator of health, the chi-square statistic is not reported. In such cases, the "zero" value is invisible to statistical programs and cannot be calculated (SPSS Statistics 17.0).

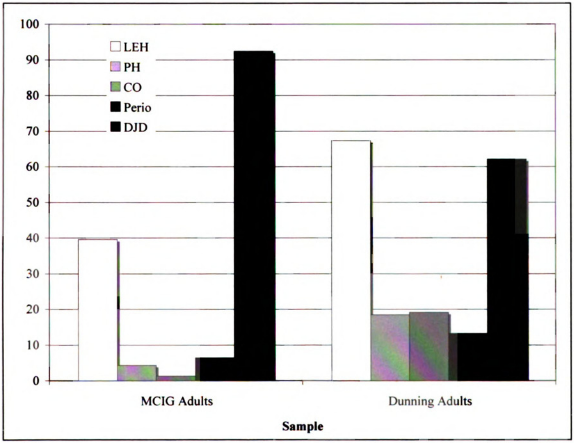
Table 31: Frequency and Prevalence Rates for the MCIG Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	78	119	197	39.6	395.9
Porotic Hyperostosis - Parietal	20	435	458	4.3	43.7
Cribra Orbitalia	6	443	448	1.3	13.4
Periostitis – Tibia	31	451	482	6.4	64.3
TB - vertebral	5	437	442	1.1	11.3
TB - ribs	4	396	400	1.0	10.0
DJD	462	38	500	92.4	924.0

Table 32: Frequency and Prevalence Rates for the Dunning Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	37	18	55	67.3	672.7
Porotic Hyperostosis - Parietal	10	44	54	18.5	185.2
Cribra Orbitalia	9	38	47	19.1	191.5
Periostitis – Tibia	7	46	53	13.2	132.1
DJD	**36**	**22**	**58**	**62.1**	**620.7**

Figure 27: Frequency of each indicator[1] of health by Adult sample (Dunning)



[1]Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Degenerative joint disease (DJD)

For each indicator of health, the adult samples from both cemeteries were also examined for any observable differences based on age and/or sex cohorts. The first of theses comparisons looked for observed sex-related differences between samples. Table 33, 34, 35, and 36 show the frequency and prevalence rates for the adult male and female samples from each cemetery. Like the pattern seen with the overall adult samples, the prevalence rates for all indicators of health were found to be higher in the Dunning sex cohorts than for the MCIG males and females. The exception was again the prevalence rate of DJD, which is higher in the MCIG sample for both males and females. For the adult males, the presence of linear enamel hypoplasias, porotic hyperostosis, cribra orbitalia, and DJD were found to be significantly different. The following chi-square statistics were established: LEH (χ^2= 7.501, df=1); porotic hyperostosis involving the parietal (χ^2= 18.487, df=1); cribra orbitalia (χ^2= 27.844, df=1); periostitis involving the tibia (χ^2= 1.050, df=1); and evidence for degenerative joint disease (χ^2= 27.389, df=1).

Significant differences were seen in the presence of linear enamel hypoplasias, cribra orbitalia, and DJD among the adult female sample. The chi-square estimates for the female sample are as follows: LEH (χ^2= .7.656, df=1); cribra orbitalia (χ^2= 5.088, df=1); periostitis involving the tibia (χ^2= 1.119, df=1); and evidence for degenerative joint disease (χ^2= 10.847, df=1). The MCIG adult female sample had no observations of porotic hyperostosis and no significance determinations could be made between samples. Figure 28 and 29 show the frequency of each indicator for the males and females in each cemetery.

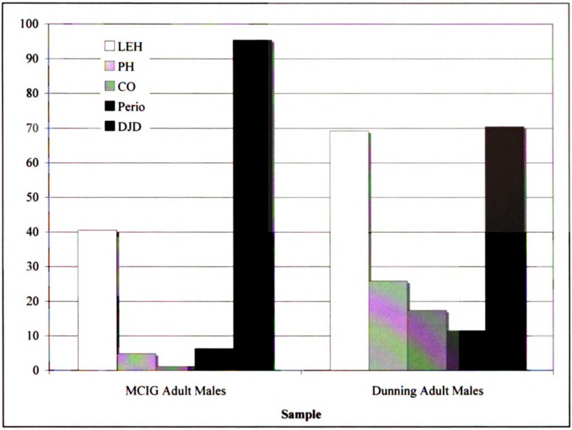
Table 33: Frequency and Prevalence Rates for the MCIG Adult Male Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	66	97	163	40.5	404.9
Porotic Hyperostosis - Parietal	18	346	364	4.9	49.5
Cribra Orbitalia	4	354	358	1.1	11.2
Periostitis – Tibia	24	354	378	6.3	63.5
TB - vertebral	3	349	352	0.9	8.5
TB - ribs	3	318	321	0.9	9.3
DJD	376	18	394	95.4	954.3

Table 34: Frequency and Prevalence Rates for the Dunning Adult Male Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	18	8	26	69.2	692.3
Porotic Hyperostosis - Parietal	7	20	27	25.9	259.3
Cribra Orbitalia	4	19	23	17.4	173.9
Periostitis – Tibia	3	23	26	11.5	115.4
DJD	19	8	27	70.4	703.7

Figure 28: Frequency of each indicator[1] of health by Adult Males (Dunning)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Degenerative joint disease (DJD)

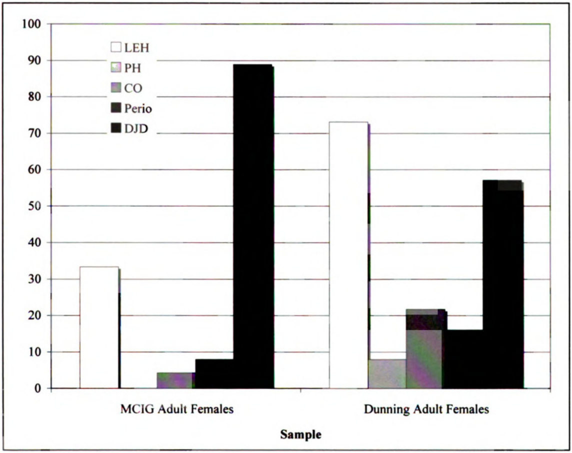
Table 35: Frequency and Prevalence Rates for the MCIG Adult Female Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	6	13	18	33.3	333.3
Porotic Hyperostosis - Parietal	0	48	48	0.0	0.0
Cribra Orbitalia	2	44	46	4.3	43.5
Periostitis – Tibia	4	46	50	8.0	80.0
TB - vertebral	1	44	45	2.2	22.2
TB - ribs	1	46	47	2.1	21.3
DJD	48	6	54	88.9	888.9

Table 36: Frequency and Prevalence Rates for the Dunning Adult Female Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	19	7	26	73.1	730.8
Porotic Hyperostosis - Parietal	2	23	25	8.0	80.0
Cribra Orbitalia	5	18	23	21.7	217.4
Periostitis – Tibia	4	21	25	16.0	160.0
DJD	16	12	28	57.1	571.4

Figure 29: Frequency of each indicator[1] of health by Adult Females (Dunning)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Degenerative joint disease (DJD)

When looking at the adult age cohorts (young, middle-aged, and old) for both samples, the Dunning sample again showed higher prevalence rates for the indicators of health examined, except when looking at observations of DJD, which was higher among the MCIG samples. Among the young adult samples, the presence of linear enamel hypoplasias and DJD were found to be significant. The chi-square statistics for these indicators are: LEH (χ^2= 5.296, df=1); porotic hyperostosis involving the parietal (χ^2= 2.670, df=1); cribra orbitalia (χ^2= 3.462, df=1); periostitis involving the tibia (χ^2= 0.763, df=1); and evidence for degenerative joint disease (χ^2= 11.240, df=1). Table 37 and 38 show the frequency and prevalence rates for the young adult samples, while Figure 30 shows the frequency of the indicators of health for the young adults.

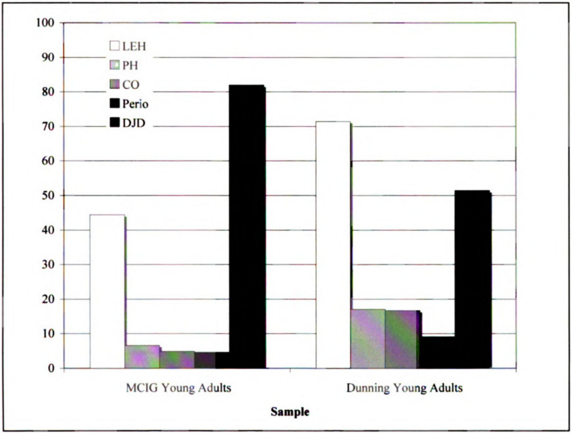
Table 37: Frequency and Prevalence Rates for the MCIG Young Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	16	20	36	44.4	444.4
Porotic Hyperostosis - Parietal	4	57	61	6.6	65.6
Cribra Orbitalia	3	58	61	4.9	49.2
Periostitis – Tibia	3	62	65	4.6	46.2
TB - vertebral	0	61	61	0.0	0.0
TB - ribs	1	60	61	1.6	16.4
DJD	59	13	72	81.9	819.4

Table 38: Frequency and Prevalence Rates for the Dunning Young Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	25	10	35	71.4	714.3
Porotic Hyperostosis - Parietal	6	29	35	17.1	171.4
Cribra Orbitalia	5	25	30	16.7	166.7
Periostitis – Tibia	3	30	33	9.1	90.9
DJD	19	18	37	51.4	513.5

Figure 30: Frequency of each indicator[1] of health by Young Adults (Dunning)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Degenerative joint disease (DJD)

The middle-aged adult cohorts between MCIG and Dunning showed significant differences for all indicators of health, except the presence of linear enamel hypoplasias. The following chi-square statistics were established: LEH (χ^2= 3.497, df=1); porotic hyperostosis involving the parietal (χ^2= 14.546, df=1); cribra orbitalia (χ^2= 41.070, df=1); periostitis involving the tibia (χ^2= 6.785, df=1); and evidence for degenerative joint disease (χ^2= 9.420, df=1). Table 39 and 40 show the frequency and prevalence rates for the middle-aged adult samples, while Figure 31 shows the frequency of the indicators of health for the middle-aged adults.

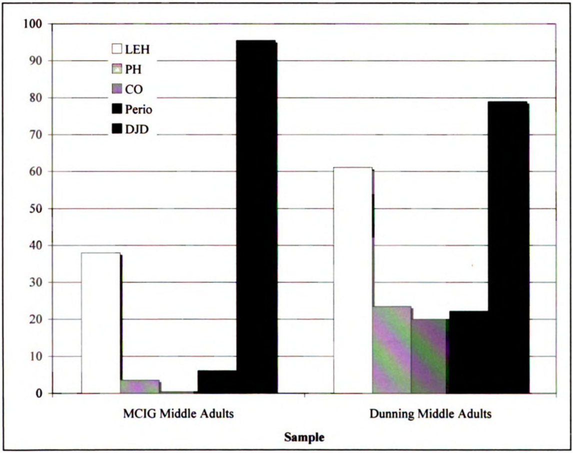
Table 39: Frequency and Prevalence Rates for the MCIG Middle-aged Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	49	80	129	38.0	379.8
Porotic Hyperostosis - Parietal	10	275	285	3.5	35.1
Cribra Orbitalia	1	279	280	0.4	3.6
Periostitis – Tibia	18	278	296	6.1	60.8
TB - vertebral	3	270	273	1.1	11.0
TB - ribs	2	249	251	0.8	8.0
DJD	295	14	309	95.5	954.7

Table 40: Frequency and Prevalence Rates for the Dunning Middle-aged Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	11	7	18	61.1	611.1
Porotic Hyperostosis - Parietal	4	13	17	23.5	235.3
Cribra Orbitalia	3	12	15	20.0	200.0
Periostitis – Tibia	4	14	18	22.2	222.2
DJD	15	4	19	78.9	789.5

Figure 31: Frequency of each indicator[1] of health by Middle-aged Adults (Dunning)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Degenerative joint disease (DJD)

The significance testing for the old adults in each sample was calculated for linear enamel hypoplasias and cribra orbitalia. Neither indicator showed significant differences. This is in part due to the sample size of the Dunning old adults, as only two individuals are represented by this age category. The chi-square statistics are LEH (χ^2= .027, df=1) and cribra orbitalia (χ^2= 13.324, df=1). No statistics were generated for porotic hyperostosis, tibial periostitis, or DJD because of zero values in the frequency data. In the case of DJD, the zero value for the Dunning frequency data was for the absence of the indicator, in other words, 100% of the Dunning old adults had observable DJD. Table 41 and 42 show the frequency and prevalence rates for the old adult samples, while Figure 32 shows the frequency of the indicators of health for the old adults.

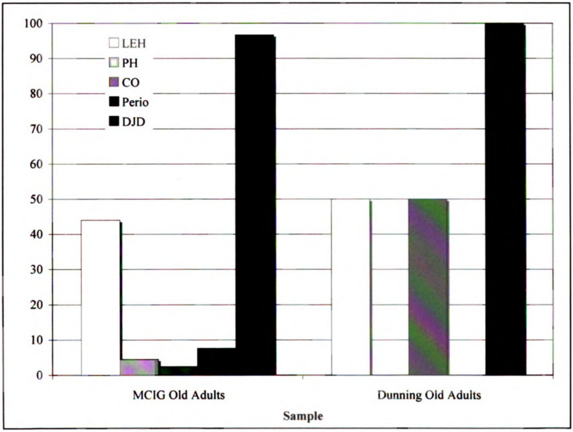
Table 41: Frequency and Prevalence Rates for the MCIG Old Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	11	14	25	44.0	440.0
Porotic Hyperostosis - Parietal	4	85	89	4.5	44.9
Cribra Orbitalia	2	83	85	2.4	23.5
Periostitis – Tibia	7	85	92	7.6	76.1
TB - vertebral	1	83	84	1.2	11.9
TB - ribs	1	75	76	1.3	13.2
DJD	89	3	92	96.7	967.4

Table 42: Frequency and Prevalence Rates for the Dunning Old Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	1	1	2	50.0	500.0
Porotic Hyperostosis - Parietal	0	2	2	0.0	0.0
Cribra Orbitalia	1	1	2	50.0	500.0
Periostitis – Tibia	0	2	2	0.0	0.0
DJD	2	0	2	100.0	1000.0

Figure 32: Frequency of each indicator[1] of health by Old Adults (Dunning)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Degenerative joint disease (DJD)

Age Differences among the Subadults from the MCIG and Dunning Poorhouse Cemeteries

The overall comparison of the subadult samples between cemeteries is summarized in table 43 and 44, which show the frequency and prevalence rates for the MCIG and Dunning subadults respectively. Unlike the adult sample, the subadult sample shows that higher prevalence rates for linear enamel hypoplasias, cribra orbitalia, and periostitis are found in the Dunning sample. The MCIG sample, however, shows higher prevalence rates for porotic hyperostosis. Two of these indicators of health, hypoplasias and cribra orbitalia, showed significant differences. The following chi-square statistics were established: LEH (χ^2= 14.316, df=1); porotic hyperostosis involving the parietal (χ^2= 3.291, df=1); cribra orbitalia (χ^2= 9.258, df=1); and periostitis involving the tibia (χ^2= 1.282, df=1). Figure 33 shows the frequency of the indicators of health for the subadults in each sample.

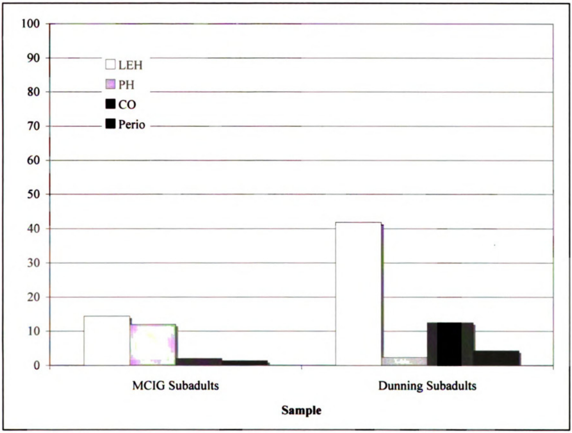
Table 43: Frequency and Prevalence Rates for the MCIG Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	34	202	236	14.4	144.1
Porotic Hyperostosis - Parietal	12	88	100	12.0	120.0
Cribra Orbitalia	4	198	202	2.0	19.8
Periostitis - Tibia	4	297	301	1.3	13.3

Table 44: Frequency and Prevalence Rates for the Dunning Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	13	18	31	41.9	419.4
Porotic Hyperostosis - Parietal	1	41	42	2.4	23.8
Cribra Orbitalia	4	28	32	12.5	125.0
Periostitis - Tibia	1	22	23	4.3	43.5

Figure 33: Frequency of each indicator[1] of health by Subadult Samples (Dunning)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (Perio)

For the infant cohorts in both MCIG and Dunning, the only chi-square statistic that was calculated was for linear enamel hypoplasias (χ^2= 14.316, df=1). No significance was found for this indicator of health despite its higher prevalence rate in the Dunning sample. The other indicators, porotic hyperostosis, cribra orbitalia, and periostitis had no observations among the Dunning infant cohort and so could not be compared to the MCIG infant cohort. Table 45 and 46 summarize the frequency and prevalence rates, while figure 34 visually displays the frequency of these indicators of health for the infant groups in each sample.

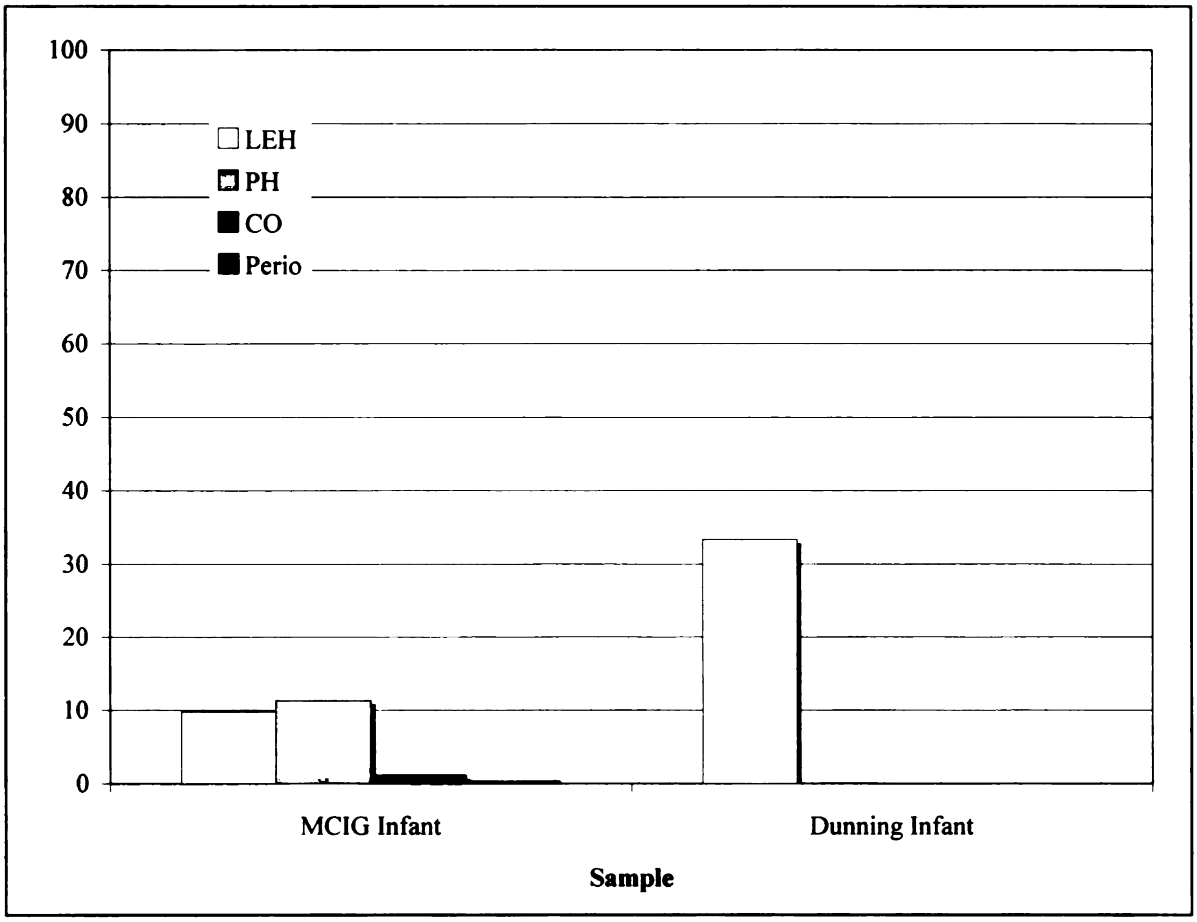
Table 45: Frequency and Prevalence Rates for the MCIG Infant Subadult Sample

Pathology	**Present**	**Absent**	**Total Number**	**Frequency %**	**Prevalence /1000**
LEH	21	193	214	9.8	98.1
Porotic Hyperostosis - Parietal	10	78	88	11.4	113.6
Cribra Orbitalia	2	170	172	1.2	11.6
Periostitis - Tibia	1	263	264	0.4	3.8

Table 46: Frequency and Prevalence Rates for the Dunning Infant Subadult Sample

Pathology	**Present**	**Absent**	**Total Number**	**Frequency %**	**Prevalence /1000**
LEH	1	2	3	33.3	333.3
Porotic Hyperostosis - Parietal	0	10	10	0.0	0.0
Cribra Orbitalia	0	7	7	0.0	0.0
Periostitis - Tibia	0	2	2	0.0	0.0

Figure 34: Frequency of each indicator[1] of health by Infant Samples (Dunning)



[1]Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (Perio)

The child cohorts for both the MCIG and Dunning cemeteries showed a significant difference between samples in regards to linear enamel hypoplasias. The MCIG sample shows a noticeably higher prevalence rate for this indicator than the Dunning sample. Chi-square statistics were generated for both hypoplasias and cribra orbitalia and are as follows: LEH (χ^2= 12.692, df=1) and cribra orbitalia (χ^2= .013, df=1). No porotic hyperostosis or periostitis was present in the child sample from Dunning and so no comparison was made between cemeteries. Tables 47 and 48 show the frequency and prevalence rates for the child groups. Figure 35 shows the frequency of each indicator of health in the samples.

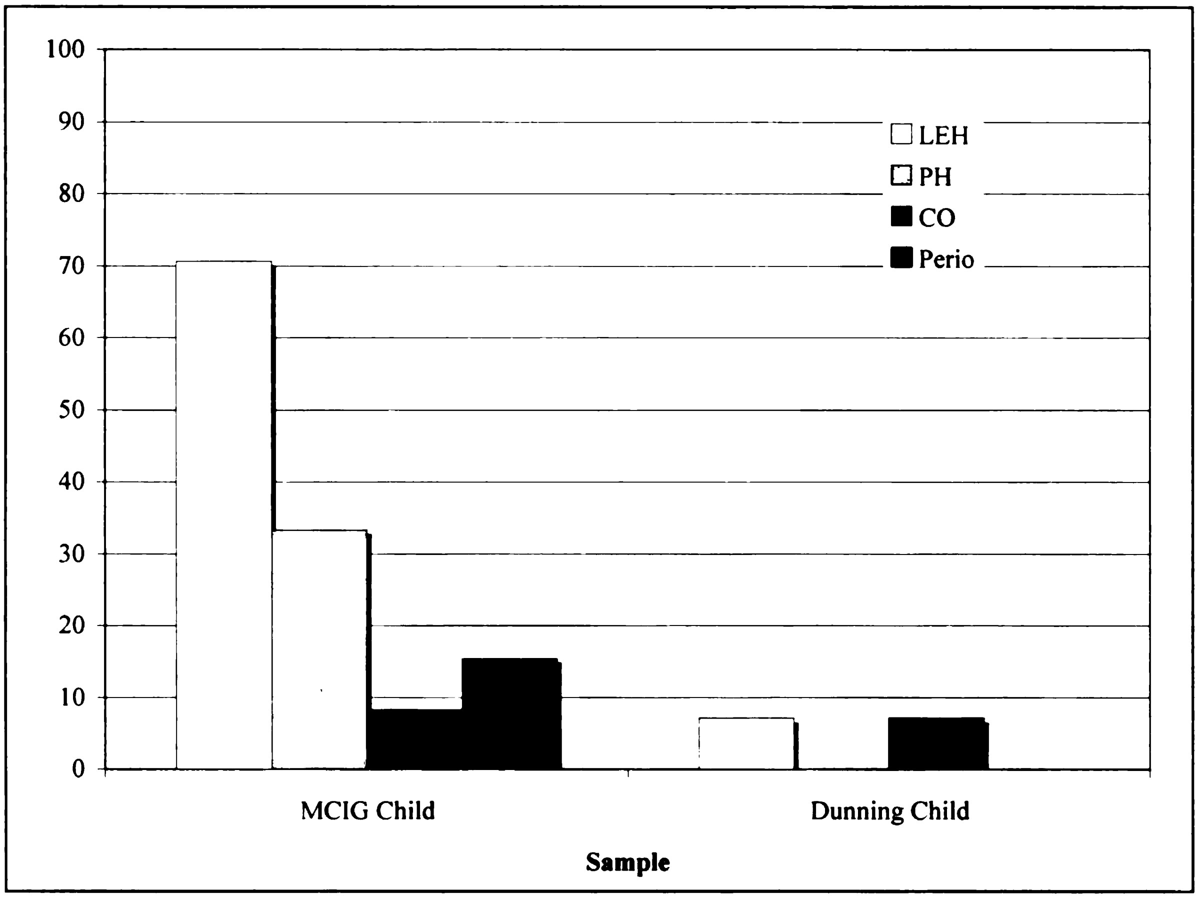
Table 47: Frequency and Prevalence Rates for the MCIG Child Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	12	5	17	70.6	705.9
Porotic Hyperostosis - Parietal	2	4	6	33.3	333.3
Cribra Orbitalia	1	11	12	8.3	83.3
Periostitis - Tibia	2	11	13	15.4	153.8

Table 48: Frequency and Prevalence Rates for the Dunning Child Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	1	13	14	7.1	71.4
Porotic Hyperostosis - Parietal	0	17	17	0.0	0.0
Cribra Orbitalia	1	13	14	7.1	71.4
Periostitis - Tibia	0	8	8	0.0	0.0

Figure 35: Frequency of each indicator[1] of health by Child Samples (Dunning)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (TP)

Like the child cohort, the juvenile groups showed a significant difference in linear enamel hypoplasias. However, unlike the previous cohort, the Dunning juvenile group exhibited the higher prevalence rate for this indicator of health. The following chi-square statistics were generated for both hypoplasias and cribra orbitalia: LEH ($\chi^2 = 5.432$, df=1) and cribra orbitalia ($\chi^2 = 0.417$, df=1). No observations of porotic hyperostosis in the MCIG group and no observations of periostitis in the Dunning group were found. Table 49 and 50 shows the frequency and prevalence rates for the groups. Figure 36 displays the frequency of the indicators of health for both MCIG and Dunning juveniles.

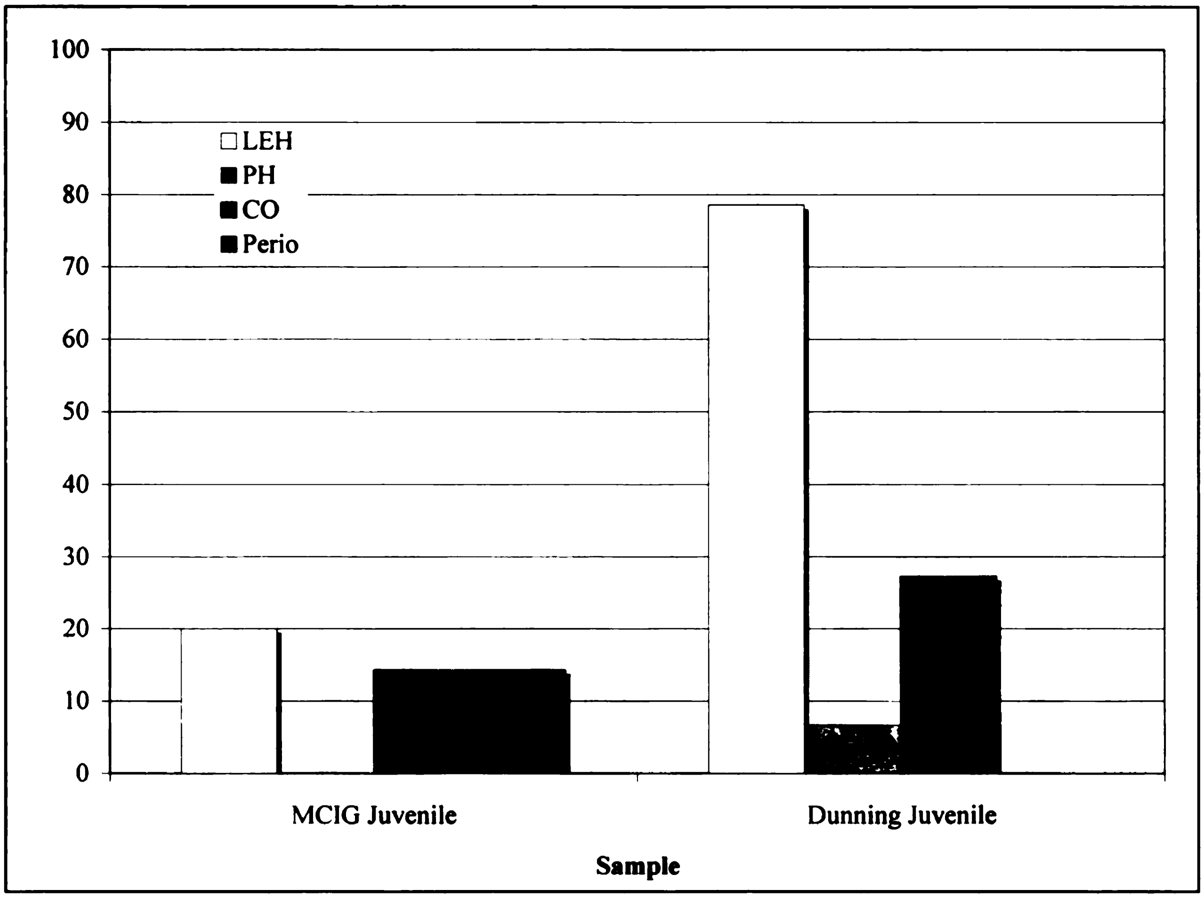
Table 49: Frequency and Prevalence Rates for the MCIG Juvenile Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	1	4	5	20.0	200.0
Porotic Hyperostosis - Parietal	0	5	5	0.0	0.0
Cribra Orbitalia	1	6	7	14.3	142.9
Periostitis - Tibia	1	6	7	14.3	142.9

Table 50: Frequency and Prevalence Rates for the Dunning Juvenile Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	11	3	14	78.6	785.7
Porotic Hyperostosis - Parietal	1	14	15	6.7	66.7
Cribra Orbitalia	3	8	11	27.3	272.7
Periostitis - Tibia	0	13	13	0.0	0.0

Figure 36: Frequency of each indicator[1] of health by Juvenile Samples (Dunning)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (Perio)

Common Odds Result for the MCIG and Dunning Poorhouse Cemeteries

As discussed in Chapter 4, common odds ratio were calculated to assess the overall sample comparisons for the MCIG and Dunning Poorhouse cemeteries. It is a useful comparison of prevalence rates when age structure and sample sizes are not consistent and as such is used for the between-group comparisons (Klaus and Tem 2009). For these calculations, the SPSS Statistics 17.0 program was used.

The test includes three steps. The Breslow-Day Test of Homogeneity of the Odds Ratio, which looks at whether or not the association between the risk factor (sample) and disease (indicator of health) is the same for each stratum (age category) (Selvin 1996).

The null hypothesis would be that any differences seen are due to random variation. When the null hypothesis is rejected, a single common odds ratio is not feasible (Selvin 1996). The Mantel-Haenszel Test of Conditional Independence looks at whether the two variables are conditionally independent in each stratum. The null hypothesis would be that the variables are independent and any differences seen as due to random variation (Selvin 1996). When the null hypothesis is rejected, the risk factor (sample) and disease (indicator of health) are associated within each age category (Selvin 1996; Kahn and Sempos 1989). The third step in the SPSS program is the Mantel-Haenszel Common Odds Ratio Estimate for the compared samples. The estimate, confidence intervals at 95%, and the significance of the estimate are calculated when the test of homogeneity is not significant and the test of conditional independence is significant. Since the assumption for the common odds ratio estimate is 1.000, confidence intervals that do not include 1.000 are significant (Selvin 1996; Waldron 2007). For the between-group comparisons, each indicator of health for both samples was tested. The common odds ratios generated provided information on whether the higher or lower prevalence for each indicator was statistically significant between samples.

For the comparison between the MCIG cemetery and the Dunning Poorhouse Cemetery, two common odds ratio estimates could be calculated. Linear enamel hypoplasias observed in each sample had an associated summary odds ratio of .288 (CI: 0.174-0.476). The significant estimate shows that the prevalence of hypoplasias is substantially lower in the MCIG sample than in the Dunning sample. Likewise, a common odds ratio for cribra orbitalia was .082 (C1: 0.035-0.194). Again, the lower prevalence for this indicator in the MCIG sample was significantly different from the Dunning sample.

Monroe County Poorhouse / Highland Park Cemetery

The Monroe County Poorhouse Cemetery / Highland Park Cemetery was discovered by the Monroe County Parks Department in 1984 during construction on public grounds (Lanphear 1988; Higgins and Sirianni 1995). The cemetery, located near Rochester, New York, was associated with the Monroe County Poorhouse complex and other nearby county institutions such as an insane asylum and penitentiary, and was in use from 1826 to the end of the civil war (Higgins and Sirianni 1995). The excavations yielded a total of 296 individuals. The excavated remains are estimated to represent about a third of the original cemetery (Lanphear 1988). Although there is no historical proof that the cemetery is associated with the Monroe County Poorhouse complex, Higgins and Sirianni (1995) can find no other explanation for the number of burials excavated at Highland Park.

The study of the Monroe County Poorhouse Cemetery / Highland Park Cemetery remains was aided by the availability of associated historical records. In addition, vital records from the Town of Brighton (township in which the poorhouse was located) and interment records from the nearby Mount Hope Cemetery were used for comparative purposes in the original study (Lanphear 1988). Records for the Rochester area show a largely immigrant population that was heavily impacted by the presence of infectious disease (Lanphear 1988; Higgins and Sirianni 1995). Lanphear (1988) reports that major causes of death for the Monroe County Poorhouse included tuberculosis, typhus, and cholera. While the prevalence of tuberculosis and typhus was higher in the poorhouse population than within the city of Rochester, the prevalence of cholera (a disease related to sanitation) was higher in the city. Higgins and Sirianni (1995) report high infant mortality in the almshouse population. Their analysis of dental health suggests that the most stressed groups were women and children. In particular, these groups experienced high levels of nutritional stress. They summarize that the available historical and skeletal data suggest that almshouses in the middle of the 19th century were breeding grounds for infectious diseases and unhealthy environments for their residents (Higgins and Sirianni 1995).

The primary source for the Monroe County data used in the current study was a dissertation by Lanphear (1988), entitled "Health and Mortality in a Nineteenth-Century Poorhouse Skeletal Sample". In particular, the report provides information on how the author categorized and collected the data. This is particularly useful as the data on the Monroe County skeletal sample was collected prior to the publication of *Standards* (1994). The report also includes an inventory of the pathology observed in the sample relative to the number of individuals with observable skeletal elements pertaining to that pathology. The presence or absence of four indicators of health were utilized in the comparison with the MCIG sample: linear enamel hypoplasias; porotic hyperostosis in the parietals; cribra orbitalia; and periostitis observed on the tibiae. In addition, the adult samples for both cemeteries included skeletal evidence of tuberculosis. Vertebral evidence of this specific disease was included as an indictor of health. A comparison of degenerative joint disease is not included as no information is available from the original study. All indicators of health are scored by individual.

Linear enamel hypoplasias observed on anterior teeth were included in the study. The frequency of this indicator of health was determined by the number of individuals with at least two observable, fully erupted anterior teeth. Porotic hyperostosis was considered for those individuals that have "crania complete enough for analysis" (Lanphear 1988). Frequencies of cribra orbitalia were calculated from the number of individuals with at least one orbital roof present. Periosteal bone reactions in individuals with at least one observable tibia were counted. However, no notes on trauma were present in the original study, and as such the observations of periosteal reactions attributed to trauma and those associated with infection are not likely differentiated in the count. Evidence for specific diseases relied on the notes from the original study that indicated when observed paleopathology might be indicative of a specific disease.

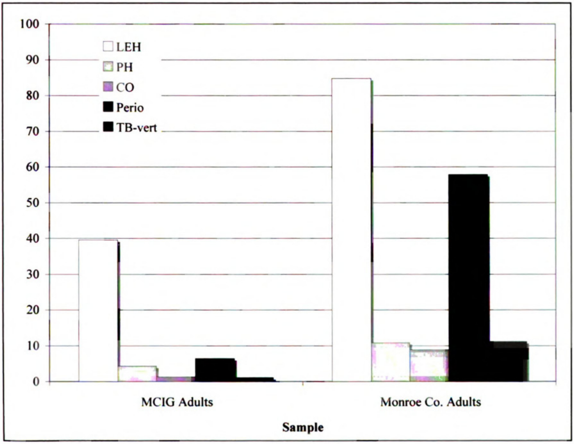
Age and Sex Differences among the Adults from the MCIG and Monroe County Poorhouse Cemeteries

The frequency and prevalence rates for the Monroe County Poorhouse Cemetery adults are summarized in table 51. When compared to the table for the MCIG adults, found in the previous section, the prevalence for all indicators of health examined are higher in the Monroe County adults than the MCIG adults. Pearson's chi-square was used to test for significance at the $p < 0.05$ levels. All indicators were found to be significant. For each, the following chi-square statistics were established: LEH ($\chi^2 = 74.519$, df=1); porotic hyperostosis ($\chi^2 = 9.238$, df=1); cribra orbitalia ($\chi^2 = 21.435$, df=1); tibial periostitis ($\chi^2 = 215.299$, df=1); and vertebral evidence for tuberculosis ($\chi^2 = 32.222$, df=1). Figure 37 shows the frequency of each indictor of health for both adult samples.

Table 51: Frequency and Prevalence Rates for the Monroe County Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	134	24	158	84.8	848.1
Porotic Hyperostosis	20	165	185	10.8	108.1
Cribra Orbitalia	15	153	168	8.9	89.3
Periostitis – Tibia	107	78	185	57.8	578.4
TB - vertebral	17	136	153	11.1	111.1

Figure 37: Frequency of each indicator[1] of health by Adult Samples (Monroe Co)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Tuberculosis – verts (TB)

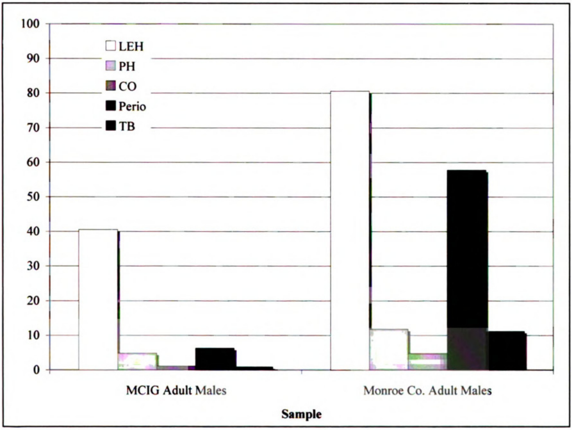
For each indicator of health, the adult samples from both cemeteries were also examined for observed sex-related differences between samples. Table 52 and 53 show the frequency and prevalence rates for the adult male and female samples from the Monroe County Poorhouse. Like the pattern seen with the overall adult samples, the prevalence rates for all indicators of health were found to be higher in the Monroe County adult male cohort than for the MCIG males. All indictors, linear enamel hypoplasias, porotic hyperostosis, cribra orbitalia, periostitis, and tuberculosis, were found to be significantly different. The following chi-square statistics were established: LEH (χ^2= 39.901, df=1); porotic hyperostosis (χ^2= 6.742, df=1); cribra orbitalia (χ^2= 5.658, df=1); tibial periostitis (χ^2= 156.105, df=1); and vertebral evidence for tuberculosis (χ^2= 27.360, df=1).

The prevalence rates for linear enamel hypoplasias, cribra orbitalia, periostitis, and tuberculosis were found to be higher for the Monroe County adult female sample. Significant differences were seen in the presence of hypoplasias and tibial periostitis among the adult female sample. The chi-square estimates for the female sample are as follows: LEH (χ^2= 29.614, df=1); cribra orbitalia (χ^2= 3.605, df=1); tibial periostitis (χ^2= 31.066, df=1); and vertebral evidence for tuberculosis (χ^2= 2.869, df=1). The MCIG adult female sample had no observations of porotic hyperostosis and no significance determinations could be made between samples. Figure 38 and 39 shows the frequency of each indicator for the males and females in each cemetery.

Table 52: Frequency and Prevalence Rates for the Monroe County Adult Male Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	79	19	98	80.6	806.1
Porotic Hyperostosis	14	105	119	11.8	117.6
Cribra Orbitalia	5	100	105	4.8	47.6
Periostitis – Tibia	67	49	116	57.8	577.6
TB	11	87	98	11.2	112.2

Figure 38: Frequency of each indicator[1] of health by Adult Males (Monroe Co)

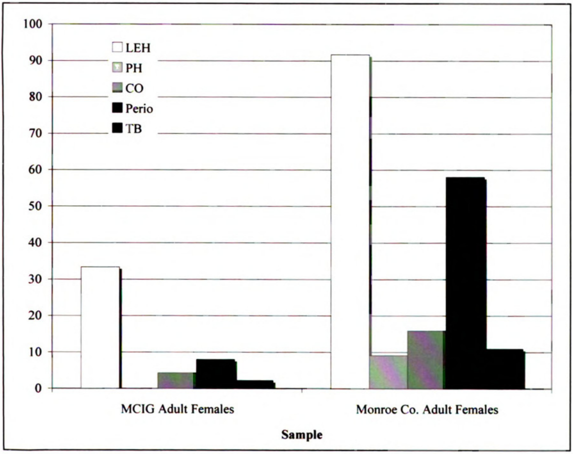


[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Tuberculosis – verts (TB)

Table 53: Frequency and Prevalence Rates for the Monroe County Adult Female Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	55	5	60	91.7	916.7
Porotic Hyperostosis	6	60	66	9.1	90.9
Cribra Orbitalia	10	53	63	15.9	158.7
Periostitis – Tibia	40	29	69	58.0	579.7
TB	6	49	55	10.9	109.1

Figure 39: Frequency of each indicator[1] of health by Adult Females (Monroe Co)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Tuberculosis – verts (TB)

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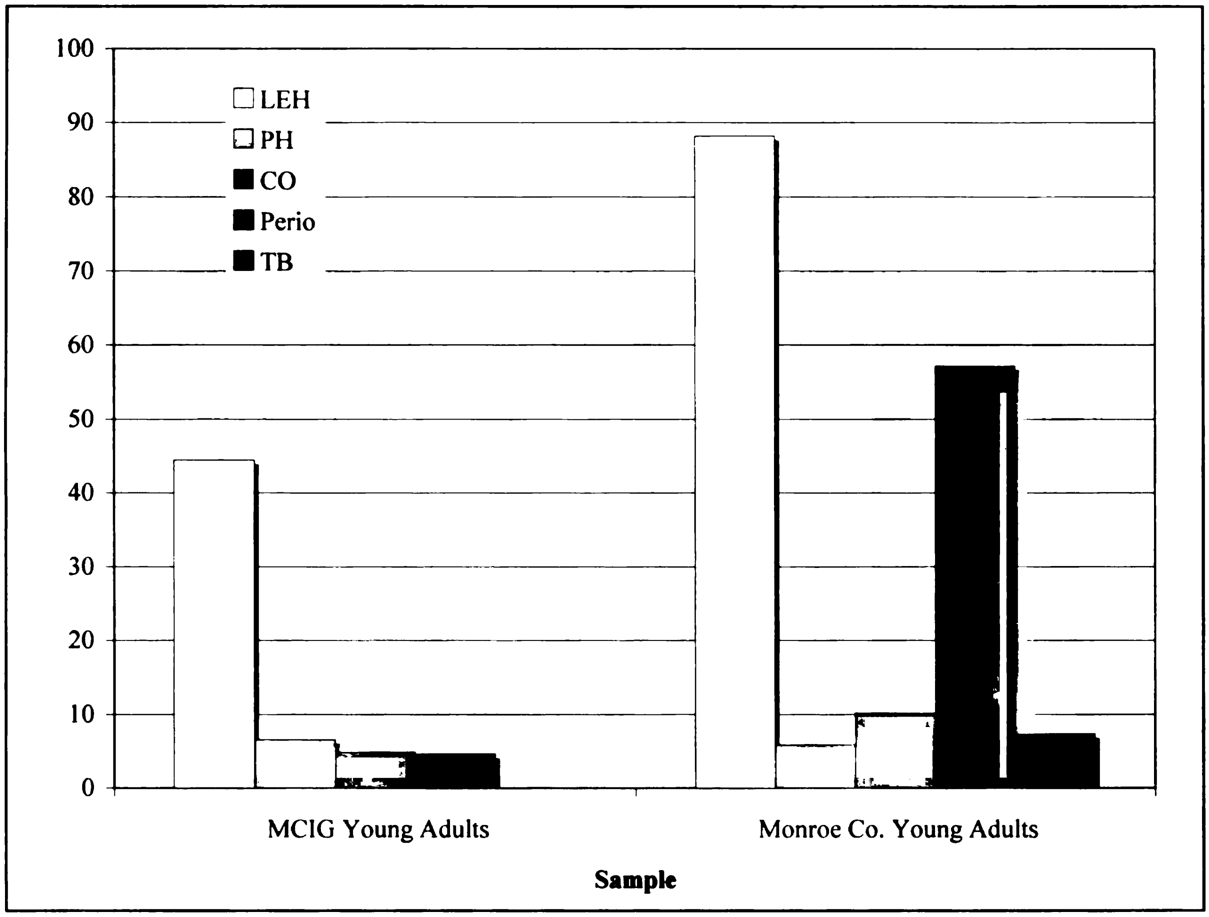
When looking at the adult age cohorts (young, middle-aged, and old) for both samples, the Monroe County sample again showed higher prevalence rates for the indicators of health examined, except when looking at observations of porotic hyperostosis, which was higher among the MCIG young adult sample. For the young adult cohorts, the presence of linear enamel hypoplasias and tibial periostitis were found to be significant. The chi-square statistics for these indicators are: LEH (χ^2= 19.313, df=1); porotic hyperostosis (χ^2= 0.022, df=1); cribra orbitalia (χ^2= 1.126, df=1); and tibial periostitis (χ^2= 38.936, df=1). No vertebral evidence for tuberculosis was present among the young adults in the MCIG sample so no chi-square statistic was generated. Table 54 shows the frequency and prevalence rates for the young adult samples, while Figure 40 shows the frequency of the indicators of health for the young adults.

Table 54: Frequency and Prevalence Rates for the Monroe County Young Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	45	6	51	88.2	882.4
Porotic Hyperostosis	3	48	51	5.9	58.8
Cribra Orbitalia	5	44	49	10.2	102.0
Periostitis – Tibia	28	21	49	57.1	571.4
TB	3	38	41	7.3	73.2

Figure 40: Frequency of each indicator[1] of health by Young Adults (Monroe Co)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Tuberculosis – verts (TB)

The middle-aged adult cohorts between MCIG and Monroe County showed significant differences for all indicators of health. The following chi-square statistics were established: LEH (χ^2= 30.889, df=1); porotic hyperostosis (χ^2= 8.450, df=1); cribra orbitalia (χ^2= 20.604, df=1); periostitis involving the tibia (χ^2=89.758, df=1); and vertebral evidence for tuberculosis (χ^2= 25.617, df=1). Table 55 shows the frequency and prevalence rates for the middle-aged adult samples, while Figure 41 shows the frequency of the indicators of health for the middle-aged adults.

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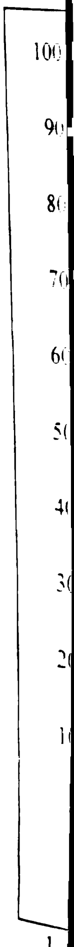
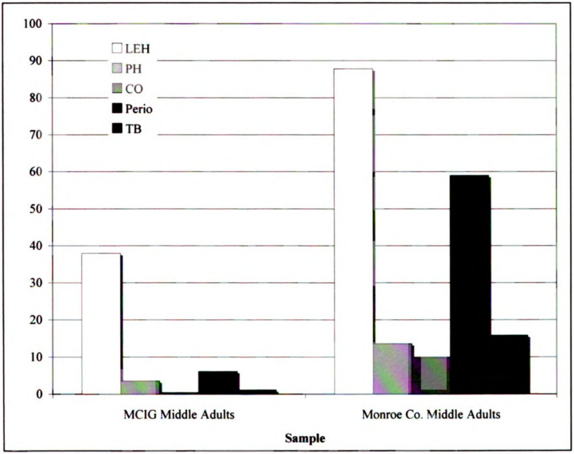


Table 55: Frequency and Prevalence Rates for the Monroe County Middle-aged Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	36	5	41	87.8	878.0
Porotic Hyperostosis	6	38	44	13.6	136.4
Cribra Orbitalia	4	37	41	9.8	97.6
Periostitis – Tibia	23	16	39	59.0	589.7
TB	6	32	38	15.8	157.9

Figure 41: Frequency of each indicator[1] of health by Middle-aged Adults (Monroe Co)



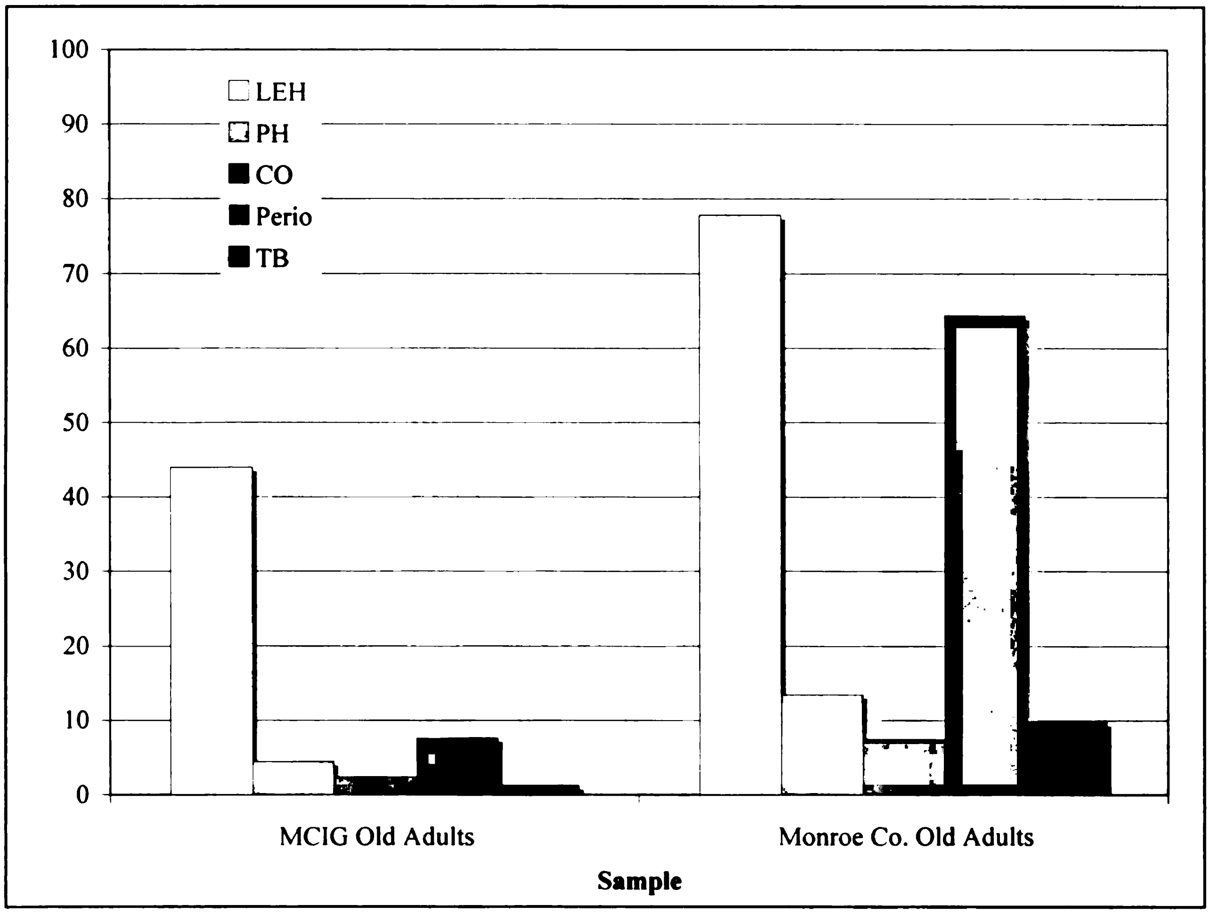
[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Tuberculosis – verts (TB)

Among the old adult cohorts, the prevalence rates for all indicators of health are higher in the Monroe County sample than the MCIG sample. Significant differences between the samples were found in all indicators except for cribra orbitalia. The chi-square statistics are: LEH (χ^2= 8.830, df=1); porotic hyperostosis (χ^2= 4.186, df=1); cribra orbitalia (χ^2= 2.227, df=1); periostitis involving the tibia (χ^2=59.592, df=1); and vertebral evidence for tuberculosis (χ^2= 5.749, df=1). Table 56 shows the frequency and prevalence rates for the Monroe County old adult cohort. Figure 42 shows the frequency of the indicators of health for the old adults between both samples.

Table 56: Frequency and Prevalence Rates for the Monroe County Old Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	42	12	54	77.8	777.8
Porotic Hyperostosis	10	64	74	13.5	135.1
Cribra Orbitalia	5	62	67	7.5	74.6
Periostitis – Tibia	47	26	73	64.4	643.8
TB	6	55	61	9.8	98.4

Figure 42: Frequency of each indicator[1] of health by Old Adults (Monroe Co)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (Perio), and Tuberculosis – verts (TB)

Age Differences among the Subadults from the MCIG and Monroe County Poorhouse Cemeteries

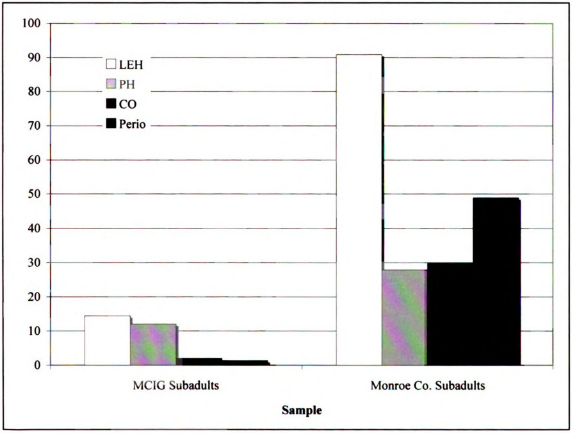
The overall comparison of the subadult sample from Monroe County is summarized in table 57, which shows the frequency and prevalence rates for the subadult. Like the adult sample, the subadult sample shows a higher prevalence rate for each indicator of health than the MCIG subadult sample. Significance testing found that the differences seen for all indicators were statistically significant. The following chi-square statistics were established: LEH (χ^2= 71.167, df=1); porotic hyperostosis (χ^2= 6.836, df=1); cribra orbitalia (χ^2= 43.962, df=1); and periostitis involving the tibia

(χ^2= 127.413, df=1). Figure 43 shows the frequency of the indicators of health for the subadults in each sample.

Table 57: Frequency and Prevalence Rates for the Monroe County Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	20	2	22	90.9	909.1
Porotic Hyperostosis	19	49	68	27.9	279.4
Cribra Orbitalia	14	33	47	29.8	297.9
Periostitis - Tibia	22	23	45	48.9	488.9

Figure 43: Frequency of each indicator[1] of health by Subadult Samples (Monroe Co)



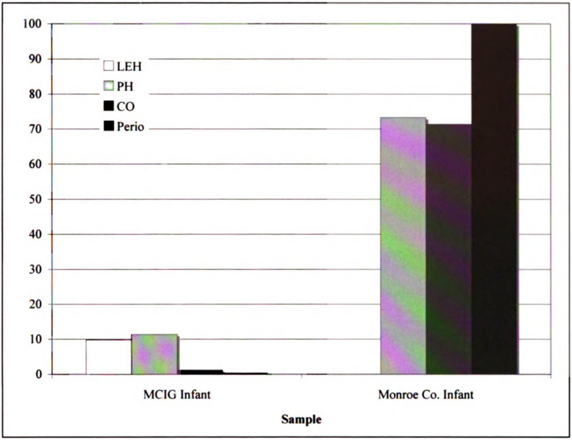
[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (Perio)

For the infant cohorts in the Monroe County Poorhouse cemetery, higher prevalence rates for porotic hyperostosis, cribra orbitalia, and periostitis were observed. Chi-square statistics were calculated was for porotic hyperostosis (χ^2= 30.321, df=1) and cribra orbitalia (χ^2= 88.377, df=1). The results for both indicators were significant. The other indicators, linear enamel hypoplasias and periostitis, each had a zero value among the Monroe County infant cohort and so could not be compared to the MCIG infant cohort. In the case of tibial periostitis, the infant sample showed that 100% of the cohort exhibited evidence of the reaction. Table 58 summarizes the frequency and prevalence rates, while figure 44 visually displays the frequency of these indicators of health for the infant groups in each sample.

Table 58: Frequency and Prevalence Rates for the Monroe County Infant Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	0	0	0	0.0	0.0
Porotic Hyperostosis	11	4	15	73.3	733.3
Cribra Orbitalia	5	2	7	71.4	714.3
Periostitis - Tibia	5	0	5	100.0	1000.0

Figure 44: Frequency of each indicator[1] of health by Infant Samples (Monroe Co)



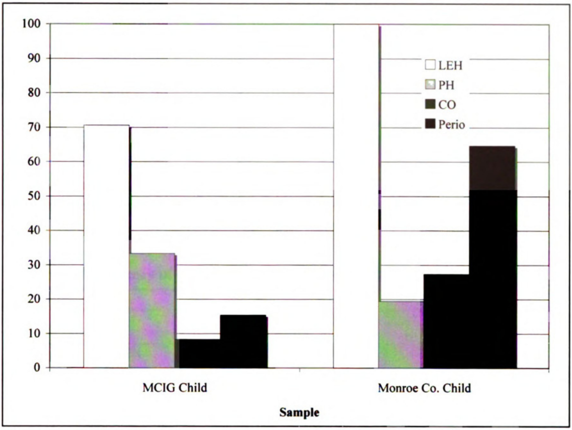
[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (Perio)

The child cohort for the Monroe County Poorhouse cemetery exhibited higher prevalence rates for all indicators of health when compared to the MCIG sample. However, only one indictor, periostitis, showed a significant difference. The following chi-square statistics were established: porotic hyperostosis ($\chi^2 = 0.580$, df=1); cribra orbitalia ($\chi^2 = 1.704$, df=1); and periostitis involving the tibia ($\chi^2 = 7.298$, df=1). No chi-square statistic was established for linear enamel hypoplasias as 100% of this sample had the observed indicator. As a note, the MCIG child cohort also showed a high frequency of linear enamel hypoplasias (70.6%). Tables 59 shows the frequency and prevalence rates for the child group from Monroe County. Figure 45 shows the frequency of each indicator of health in the samples.

Table 59: Frequency and Prevalence Rates for the Monroe County Child Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	2	0	2	100.0	1000.0
Porotic Hyperostosis	6	25	31	19.4	193.5
Cribra Orbitalia	6	16	22	27.3	272.7
Periostitis - Tibia	11	6	17	64.7	647.1

Figure 45: Frequency of each indicator[1] of health by Child Samples (Monroe Co)



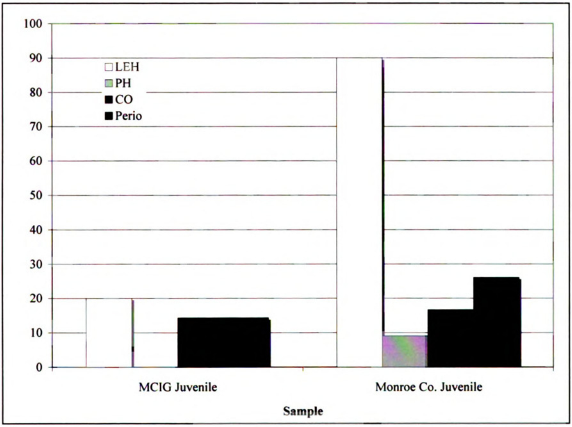
[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (Perio)

The juvenile cohort for Monroe County also showed a higher prevalence rate for all indicators of health. Like the child cohort, the juvenile groups showed only one indicator as significant, linear enamel hypoplasias. The following chi-square statistics were generated: linear enamel hypoplasias ($\chi^2 = 10.746$, df=1); cribra orbitalia ($\chi^2 = 0.021$, df=1); and periostitis involving the tibia ($\chi^2 = 0.418$, df=1). No observations of porotic hyperostosis in the MCIG group were found. Table 60 shows the frequency and prevalence rates for Monroe County. Figure 46 displays the frequency of the indicators of health for both MCIG and Monroe County juveniles.

Table 60: Frequency and Prevalence Rates for the Monroe County Juvenile Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	18	2	20	90.0	900.0
Porotic Hyperostosis - Parietal	2	20	22	9.1	90.9
Cribra Orbitalia	3	15	18	16.7	166.7
Periostitis - Tibia	6	17	23	26.1	260.9

Figure 46: Frequency of each indicator[1] of health by Juvenile Samples (Monroe Co)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (TP)

Common Odds Result for the MCIG and Monroe County Poorhouse Cemeteries

Two common odds ratio estimates could be calculated for the between-group comparison between MCIG and Monroe County. Porotic hyperostosis observed in each sample had an associated summary odds ratio of 0.368 (CI: 0.222-0.608). The significant estimate shows that the prevalence of porotic hyperostosis is lower in the MCIG sample than in the Monroe County sample. A common odds ratio for cribra orbitalia was also calculated. The summary statistic was 0.092 (C1: 0.044-0.193). The lower prevalence for this indicator in the MCIG sample was significantly different from the Monroe County sample.

Voegtly Cemetery

The Voegtly Cemetery was discovered in 1987 during the construction of the East Street Valley Expressway north of Pittsburgh. Associated with the Voegtly Evangelical Lutheran Church, the cemetery was in use from 1833 until 1861, when a new cemetery was established at a separate location (*Human Remains from Voegtly Cemetery* 2003). The 1987 excavations yielded a total of 744 burials out of an expected 823 based on burial records for the Voegtly Cemetery (*Human Remains from Voegtly Cemetery* 2003).

Like the other samples used in the current study, historical records associated with the skeletal sample provided contextual evidence of the lives of those interred in the cemetery. The edited report by Ubelaker and Jones (*Human Remains from Voegtly Cemetery* 2003) describes the environment surrounding the Voegtly community as an increasing urban area. Urban issues with overcrowding, poor sanitation, inadequate nutrition, and disease were common for all city residents. Church records show that the Voegtly community experienced high infant mortality rates as the community struggled with infectious diseases such as tuberculosis, cholera, malaria, typhoid fever, and yellow fever. The burial record for Voegtly cemetery, when causes of death are listed with entries, shows that most causes of death were the result of epidemics (*Human Remains from Voegtly Cemetery* 2003).

The source for the Voegtly data is the edited report by Ubelaker and Jones, *Human Remains from Voegtly Cemetery* (2003). The study of the Voegtly Cemetery skeletal remains included observations of skeletal pathology that examined the health of the population buried in the cemetery. These observations included the following: evidence of trauma; periosteal lesions associated with both traumatic and non-specific causative factors; non-specific lytic lesions; evidence of specific diseases, including tuberculosis; arthritic conditions; Harris lines; and cribra orbitalia (*Human Remains from Voegtly Cemetery* 2003). In addition, dental health was evaluated with the presence of carious lesions, alveolar abscesses, antemortem tooth loss, enamel hypoplasias, and occlusal wear (*Human Remains from Voegtly Cemetery* 2003). The report includes a summary of individual burial information, which lists the burial number, age and/or sex information, and pathological comments. Also included are detailed burial descriptions for each excavated burial. This section includes the material and skeletal inventories for each individual.

Mirroring the other samples, the presence and absence of four indicators of health were used for the comparative analysis: linear enamel hypoplasias; porotic hyperostosis; cribra orbitalia; and periostitis observed on the tibiae. The data for Voegtly also provided evidence for tuberculosis in both the vertebrae and ribs, as well as, evidence of degenerative joint disease in adults. The inventories included in the burial descriptions were used to count the number of individuals with observable skeletal elements pertaining to paleopathological conditions. As a note, while porotic hyperostosis is listed as an indicator of health, no observations of this indicator are mentioned in the report for Voegtly Cemetery despite evidence for cribra orbitalia. As such, all age and sex cohorts show the absence of this indicator. All indicators of health are reported by individual.

Linear enamel hypoplasias observed on anterior teeth were included in the study. The frequency of this indicator of health was determined by the number of individuals with at least two observable anterior teeth. Frequencies of cribra orbitalia were calculated from the number of individuals with the frontal bone present. Periosteal bone reactions were counted for individuals where at least a third of the tibial shaft was present. These reactions were limited to the burials the authors of the original study list as "periosteal lesions of non-traumatic origin" (*Human Remains from Voegtly Cemetery* 2003). Evidence for degenerative joint disease (DJD) was counted for all adults with age and/or sex estimations.

Evidence for specific diseases relied on the notes from the original study that indicated when observed paleopathology might be indicative of tuberculosis. In particular, the original study found four individuals with possible skeletal evidence of this disease. A molecular analysis identifying DNA from the *Mycobacterium tuberculosis* complex was conducted for three of these individuals, as well as, three controls presenting no skeletal evidence for tuberculosis. Two of the individuals and one control (an infant) tested positive for *M. tuberculosis* (*Human Remains from Voegtly Cemetery* 2003). The two positive individuals and a fourth, untested individual with similar skeletal evidence are included in the counts for tuberculosis in the comparison with the MCIG sample. The frequency for tuberculosis is established separately for those individuals with thoracic vertebrae and ribs present.

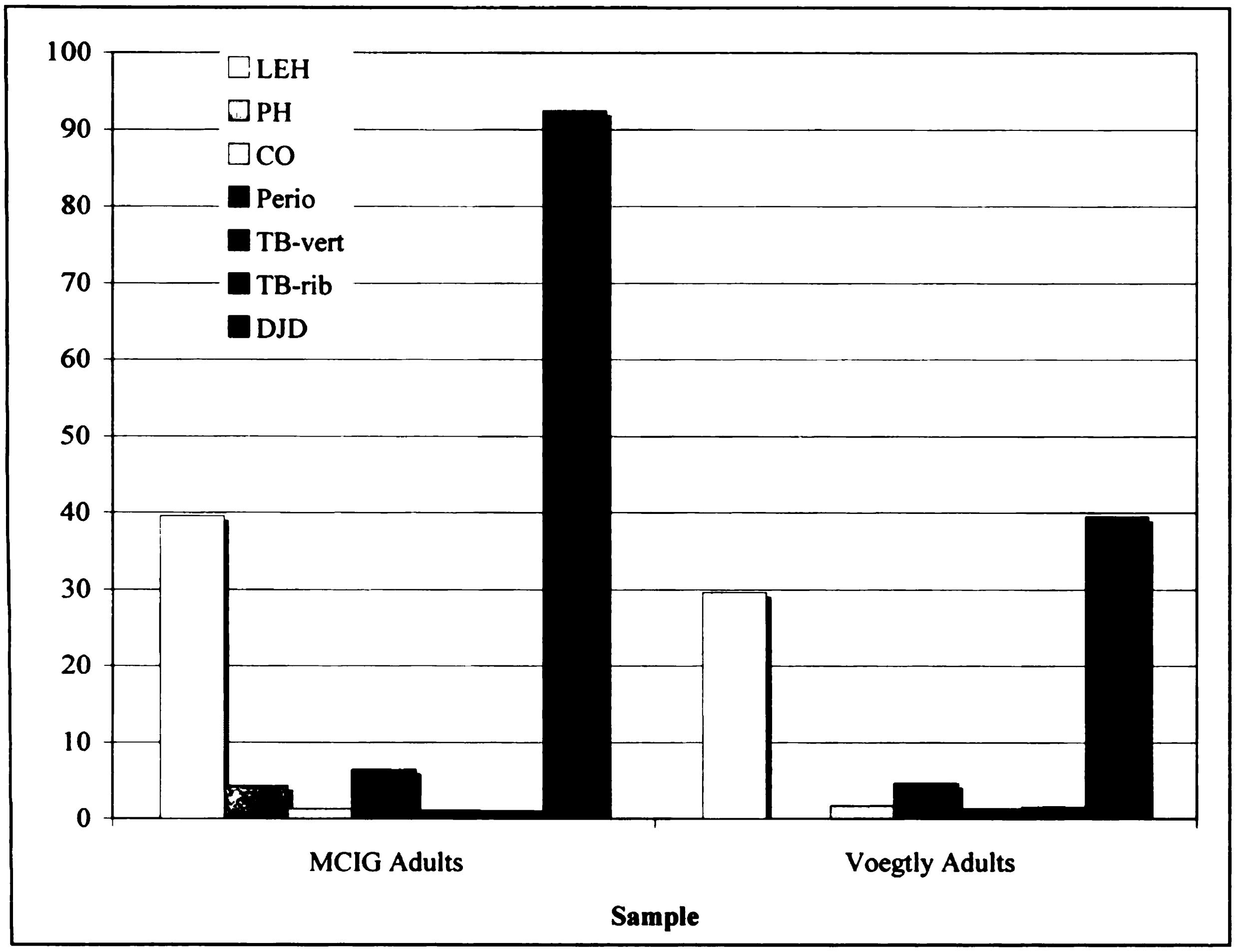
Age and Sex Differences among the Adults from the MCIG and Voegtly Cemeteries

The frequency and prevalence rates for the Voegtly Cemetery adults are summarized in table 61. The comparisons between the MCIG sample and the Voegtly sample showed the most similarities between all samples included in the current study. While differences in the prevalence rates of indicators of health were observed, few were significant. In addition, among the adults, several age and sex cohorts for Voegtly (i.e. females and old adults) showed the absence of any evidence of a number of indicators. The MCIG adult sample showed a higher prevalence for linear enamel hypoplasias, periostitis, and DJD. The Voegtly adult sample showed a higher prevalence rate for cribra orbitalia and evidence of tuberculosis in both the vertebrae and ribs. Again, no evidence for porotic hyperostosis was present in the adult sample. The only indicator of health found to be significant was the presence of DJD. The following chi-square statistics were established: LEH (χ^2= 3.327, df=1); cribra orbitalia (χ^2= 0.106, df=1); tibial periostitis (χ^2= 0.595, df=1); vertebral evidence for tuberculosis (χ^2= 0.026, df=1); evidence for tuberculosis in the ribs (χ^2= 0.128, df=1); and DJD (χ^2= 204.546, df=1). Figure 47 shows the frequency of each indictor of health for both adult samples.

Table 61: Frequency and Prevalence Rates for the Voegtly Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	37	88	125	29.6	296.0
Porotic Hyperostosis-Parietal	0	139	139	0.0	0.0
Cribra Orbitalia	2	113	115	1.7	17.4
Periostitis – Tibia	6	124	130	4.6	46.2
TB - Vertebral	1	74	75	1.3	13.3
TB - Ribs	1	67	68	1.5	14.7
DJD	60	92	152	39.5	394.7

Figure 47: Frequency of each indicator[1] of health by Adult Samples (Voegtly)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (TP), Tuberculosis – verts (TB-vert), Tuberculosis – ribs (TB-ribs) Degenerative joint disease (DJD)

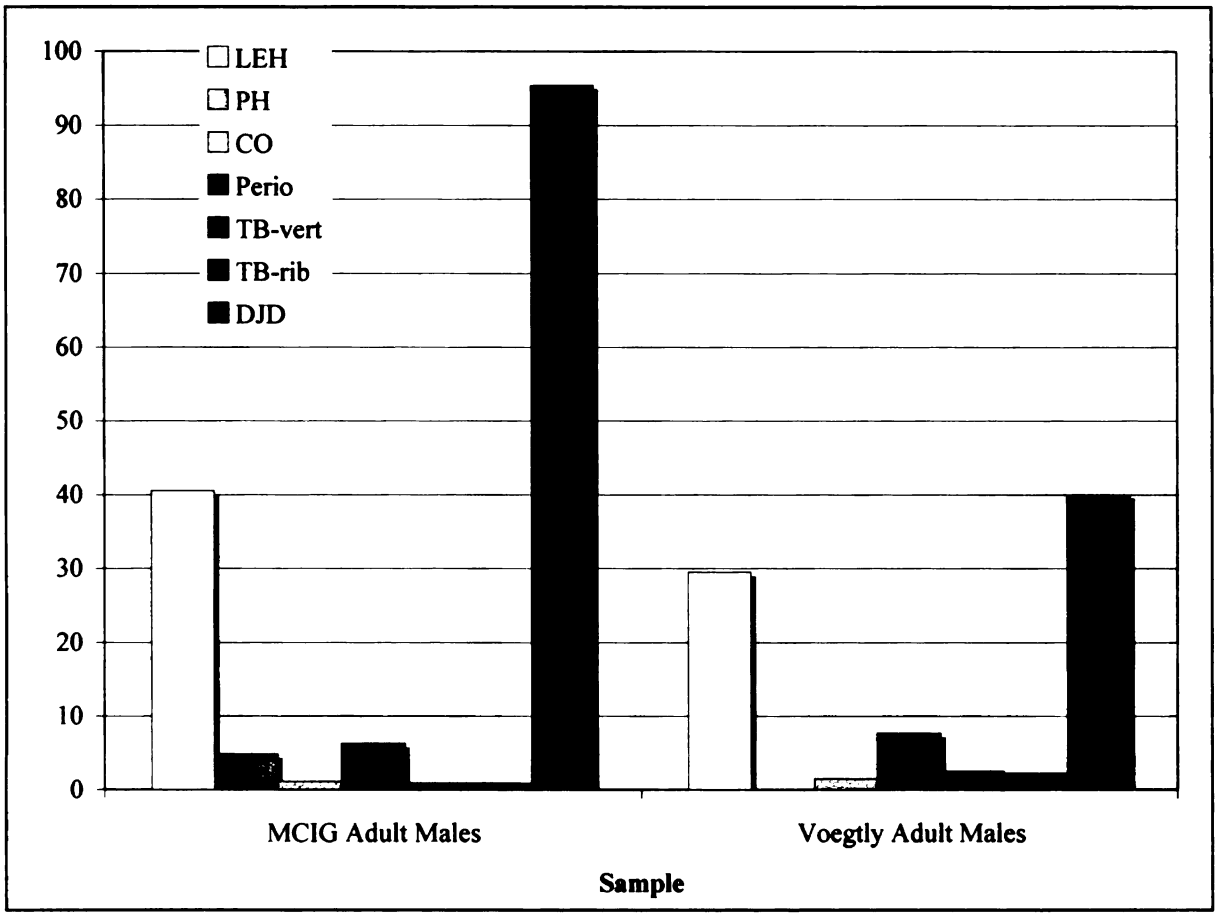
The adult samples from both cemeteries were also examined for observed sex-related differences between samples. Table 62 and 63 show the frequency and prevalence rates for the adult male and female samples from the Voegtly cemetery. The adult males in the MCIG sample showed higher prevalence rates for linear enamel hypoplasias and DJD. Prevalence rates for cribra orbitalia, tibial periostitis, and evidence for tuberculosis in both the vertebrae and ribs was higher in the Voegtly adult male sample. Again, the only indicator of health to show a significant difference was DJD. The following chi-square statistics were established: LEH (χ^2= 2.742, df=1); cribra orbitalia (χ^2= 0.084, df=1); tibial periostitis (χ^2= 0.190, df=1); vertebral evidence for tuberculosis (χ^2= 0.585, df=1); evidence for tuberculosis in the ribs (χ^2= 0.605, df=1); and DJD (χ^2= 177.774, df=1).

The prevalence rates for linear enamel hypoplasias, cribra orbitalia, and DJD were found to be higher for the MCIG adult female sample. Of these, only the difference seen with DJD was significant. The Voegtly adult female sample showed no evidence for periostitis. Both samples showed no evidence for tuberculosis in either the vertebrae or the ribs. The chi-square estimates for the female sample are as follows: LEH (χ^2= .000, df=1); cribra orbitalia (χ^2= 0.390, df=1); and DJD (χ^2= 28.346, df=1). Figure 48 and 49 shows the frequency of each indicator for the males and females in each cemetery.

Table 62: Frequency and Prevalence Rates for the Voegtly Adult Male Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	23	55	78	29.5	294.9
Porotic Hyperostosis-Parietal	0	83	83	0.0	0.0
Cribra Orbitalia	1	64	65	1.5	15.4
Periostitis – Tibia	6	72	78	7.7	76.9
TB - Vertebral	1	49	40	2.5	25.0
TB - Ribs	1	44	45	2.2	22.2
DJD	36	54	90	40.0	400.0

Figure 48: Frequency of each indicator[1] of health by Adult Males (Voegtly)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (TP), Tuberculosis – vert (TB-vert), Tuberculosis – rib (TB-rib), Degenerative joint disease (DJD)

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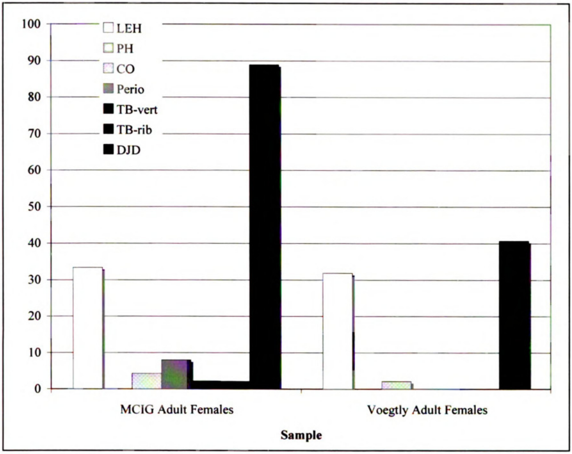
Table 63: Frequency and Prevalence Rates for the Voegtly Adult Female Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	14	30	44	31.8	318.2
Porotic Hyperostosis-Parietal	0	54	54	0.0	0.0
Cribra Orbitalia	1	47	48	2.1	20.8
Periostitis – Tibia	0	50	50	0.0	0.0
TB - Vertebral	0	24	24	0.0	0.0
TB - Ribs	0	23	23	0.0	0.0
DJD	24	35	59	40.7	406.8

Figure 49: Frequency of each indicator[1] of health by Adult Females (Voegtly)



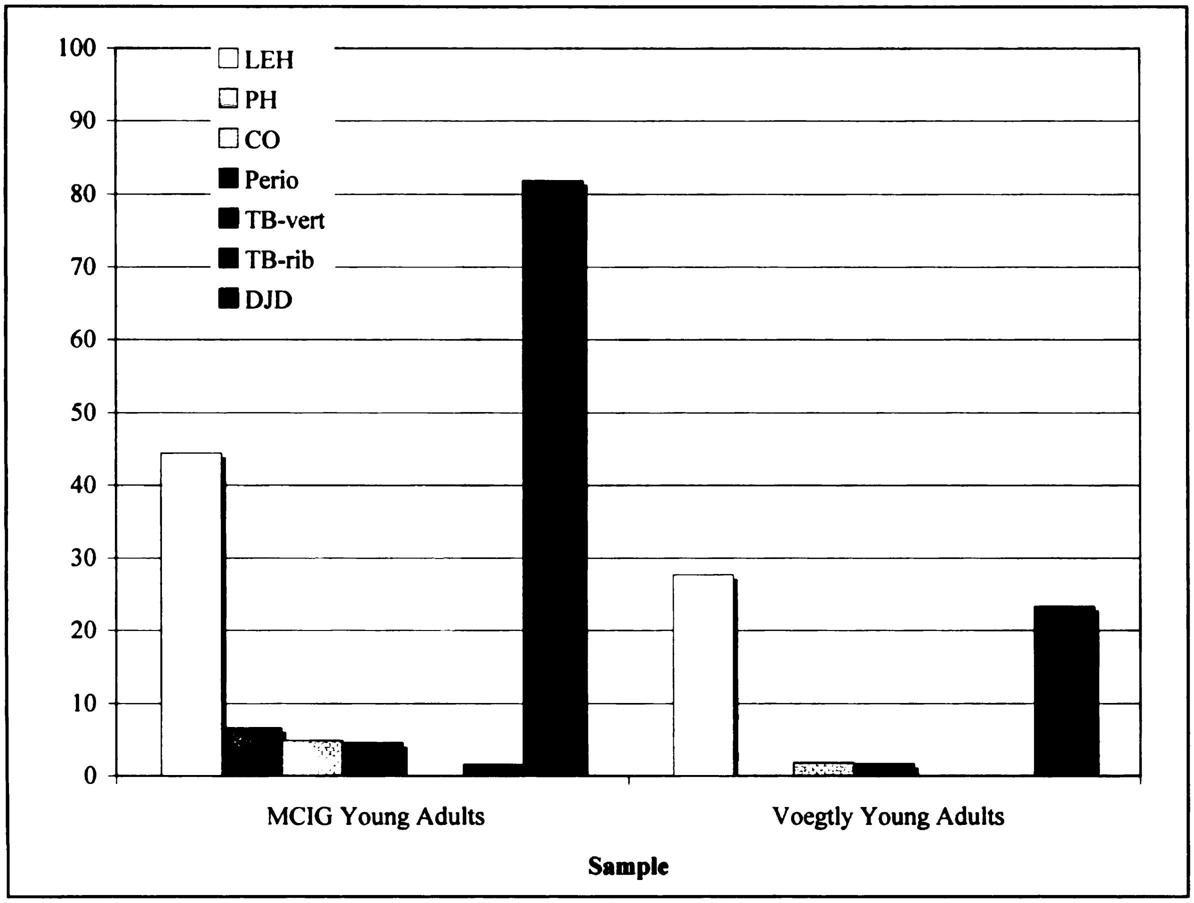
[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (TP), Tuberculosis – verts (TB), Tuberculosis – ribs (TB-rib), Degenerative joint disease (DJD)

When looking at the young adult age cohorts for both samples, the MCIG sample showed higher prevalence rates for linear enamel hypoplasias, cribra orbitalia, periostitis, and DJD. Only the presence of DJD was found to be significant. The chi-square statistics for these indicators are: LEH (χ^2= 2.912, df=1); cribra orbitalia (χ^2= 0.868, df=1); tibial periostitis (χ^2= 0.845, df=1); and DJD (χ^2= 50.003, df=1). No vertebral evidence for tuberculosis was present among the young adults in either sample, however, one MCIG young adult showed evidence for this disease in the ribs. Table 64 shows the frequency and prevalence rates for the young adult samples, while Figure 50 shows the frequency of the indicators of health for the young adults.

Table 64: Frequency and Prevalence Rates for the Voegtly Young Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	18	47	65	27.7	276.9
Porotic Hyperostosis-Parietal	0	68	68	0.0	0.0
Cribra Orbitalia	1	55	56	1.8	17.9
Periostitis – Tibia	1	58	59	1.7	16.9
TB - Vertebral	0	40	40	0.0	0.0
TB - Ribs	0	38	38	0.0	0.0
DJD	17	56	73	23.3	232.9

Figure 50: Frequency of each indicator[1] of health by Young Adults (Voegtly)



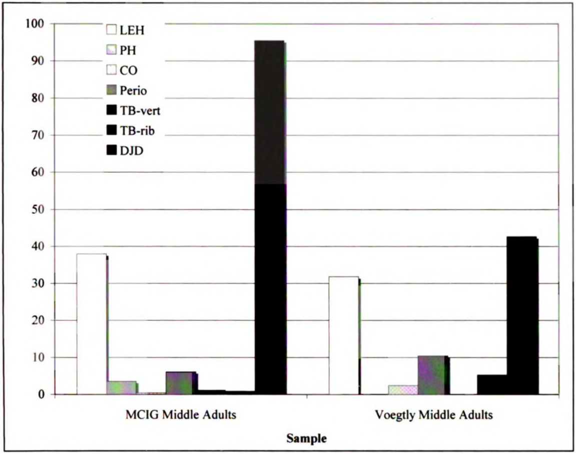
[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (TP), Tuberculosis – verts (TB-vert), Tuberculosis – ribs (TB-rib), Degenerative joint disease (DJD)

The middle-aged adult cohorts between MCIG and Voegtly also showed significant differences for only the presence of DJD. MCIG middle-aged adults showed a higher prevalence for linear enamel hypoplasias and DJD, while the Voegtly cohort showed a higher prevalence for cribra orbitalia, periostitis, and evidence for tuberculosis in the ribs. The following chi-square statistics were established: LEH (χ^2= 0.539, df=1); cribra orbitalia (χ^2= 02.423, df=1); tibial periostitis (χ^2= 1.244, df=1); evidence for tuberculosis in the ribs (χ^2= 3.207, df=1); and DJD (χ^2= 118.344, df=1). The Voegtly sample for middle-aged males showed no vertebral evidence of tuberculosis, while the MCIG sample showed such evidence in one individual. Table 65 shows the frequency and prevalence rates for the middle-aged adult samples, while Figure 51 shows the frequency of the indicators of health for the middle-aged adults.

Table 65: Frequency and Prevalence Rates for the Voegtly Middle-aged Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	14	30	44	31.8	318.2
Porotic Hyperostosis-Parietal	0	51	51	0.0	0.0
Cribra Orbitalia	1	41	42	2.4	23.8
Periostitis – Tibia	5	43	48	10.4	104.2
TB - Vertebral	0	24	24	0.0	0.0
TB - Ribs	1	18	19	5.3	52.6
DJD	23	31	54	42.6	425.9

Figure 51: Frequency of each indicator[1] of health by Middle-aged Adults (Voegtly)



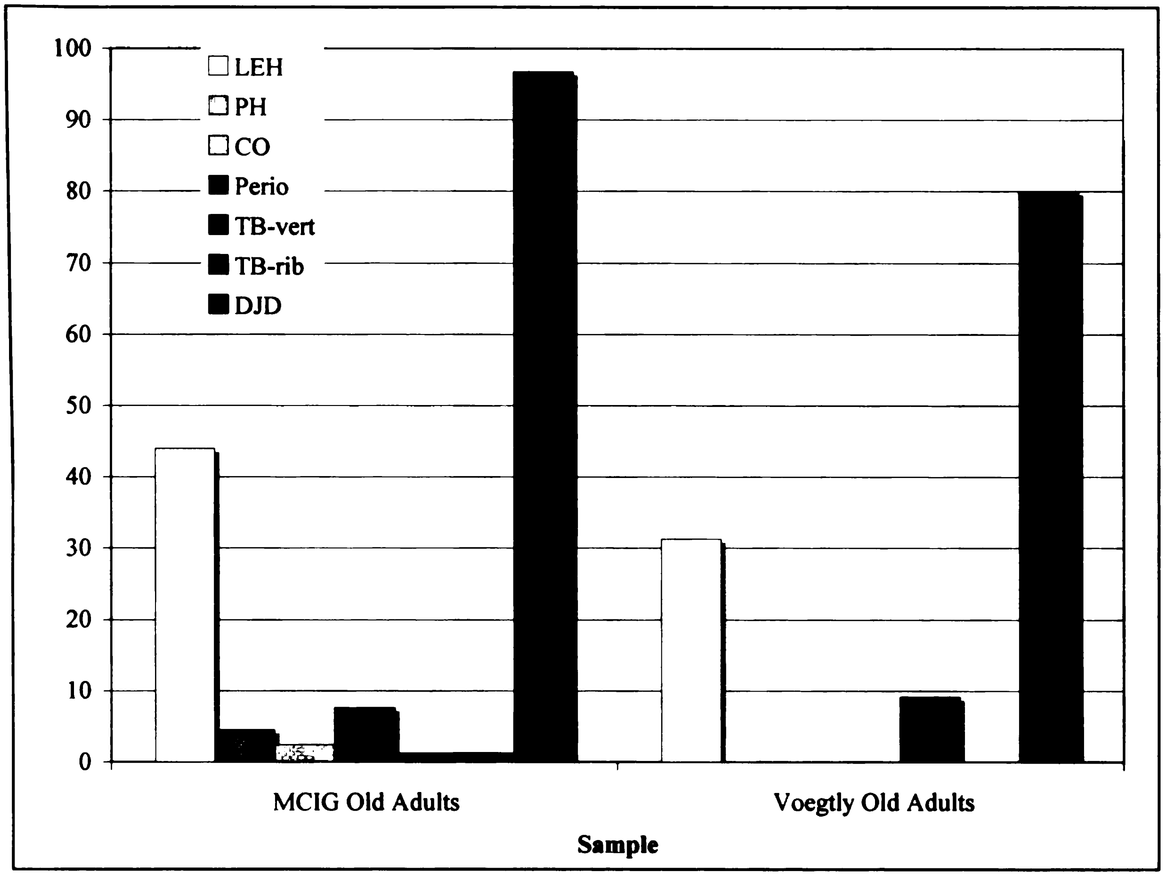
[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (TP), Tuberculosis – verts (TB-vert), Tuberculosis – ribs (TB-rib), Degenerative joint disease (DJD)

Among the old adult cohorts, the prevalence rates for linear enamel hypoplasias and DJD are higher in the MCIG sample than the Voegtly sample. However, the Voegtly sample shows a higher prevalence for vertebral evidence of tuberculosis. Significant differences between the samples was found for DJD The chi-square statistics are: LEH (χ^2= 0.667, df=1); vertebral evidence for tuberculosis (χ^2= 2.946, df=1); and DJD (χ^2= 8.647, df=1). Table 66 shows the frequency and prevalence rates for the Voegtly old adult cohort. Figure 52 shows the frequency of the indicators of health for the old adults between both samples.

Table 66: Frequency and Prevalence Rates for the Voegtly Old Adult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	5	11	16	31.3	312.5
Porotic Hyperostosis	0	20	20	0.0	0.0
Cribra Orbitalia	0	17	17	0.0	0.0
Periostitis – Tibia	0	23	23	0.0	0.0
TB - Vertebral	1	10	11	9.1	90.9
TB - Ribs	0	11	11	0.0	0.0
DJD	20	5	25	80.0	800.0

Figure 52: Frequency of each indicator[1] of health by Old Adults (Voegtly)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), Periostitis in the tibia (TP), Tuberculosis – verts (TB-vert), Tuberculosis – ribs (TB-rib), Degenerative joint disease (DJD)

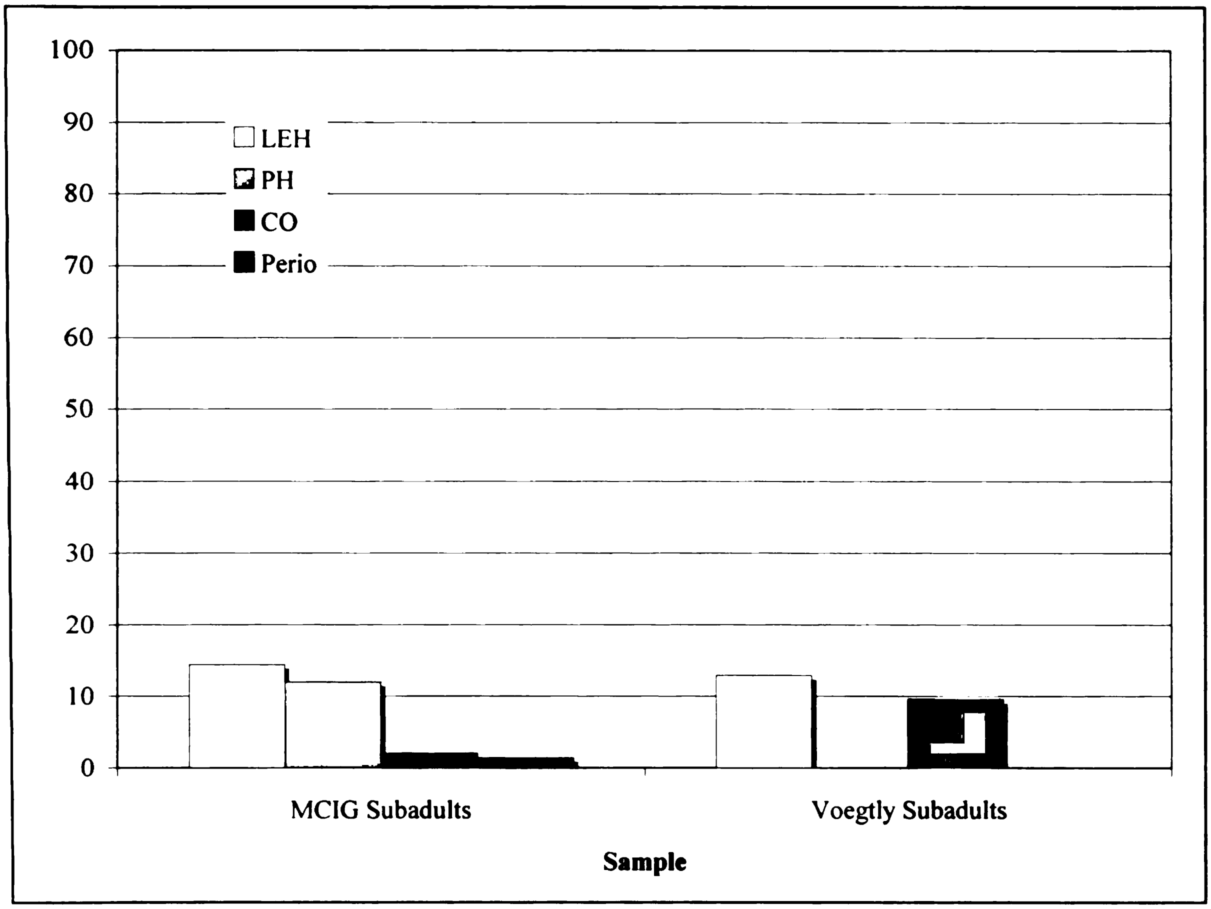
Age Differences among the Subadults from the MCIG and Voegtly Cemeteries

The overall comparison of the subadult sample from Voegtly is summarized in table 67, which show the frequency and prevalence rates for the subadults. The MCIG subadults show a higher prevalence rate for linear enamel hypoplasias. The Voegtly subadults show a higher prevalence rate for cribra orbitalia, which was also the only significant result. In general, the Voegtly subadults show very little evidence of any of the indicators of health, and like the adults, no observations of porotic hyperostosis were noted. In addition, no Voegtly subadults showed evidence for tibial periostitis. The following chi-square statistics were established: LEH ($\chi^2 = 0.224$, df=1) and cribra orbitalia ($\chi^2 = 8.811$, df=1). Figure 53 shows the frequency of the indicators of health for the subadults in each sample.

Table 67: Frequency and Prevalence Rates for the Voegtly Subadult Sample

Pathology	**Present**	**Absent**	**Total Number**	**Frequency %**	**Prevalence /1000**
LEH	31	209	240	12.9	129.2
Porotic Hyperostosis-Parietal	0	81	81	0.0	0.0
Cribra Orbitalia	9	85	94	9.6	95.7
Periostitis - Tibia	0	69	69	0.0	0.0

Figure 53: Frequency of each indicator[1] of health by Subadult Samples (Voegtly)



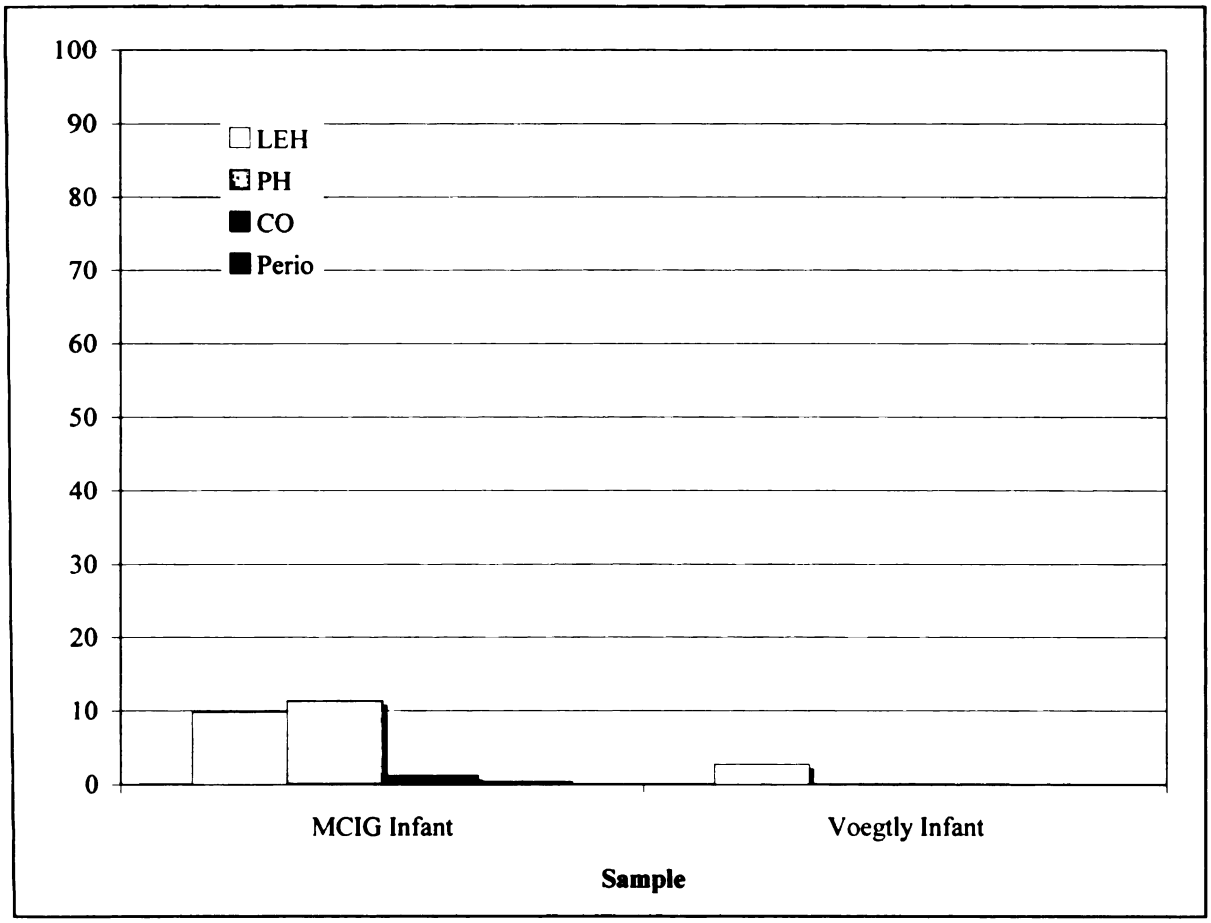
[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (Perio)

For the infant cohorts in the Monroe County Poorhouse cemetery, the only indicator that was present in both samples was linear enamel hypoplasia. The MCIG infants showed a higher prevalence rate for this indicator, but it was not found to be significant. No observations for cribra orbitalia for noted for the Voegtly infant sample. The chi-square statistics for linear enamel hypoplasias was calculated as ($\chi^2 = 3.783$, df=1). Table 68 summarizes the frequency and prevalence rates, while figure 54 visually displays the frequency of these indicators of health for the infant groups in each sample.

Table 68: Frequency and Prevalence Rates for the Voegtly Infant Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	2	72	74	2.7	27.0
Porotic Hyperostosis-Parietal	0	15	15	0.0	0.0
Cribra Orbitalia	0	25	25	0.0	0.0
Periostitis - Tibia	0	9	9	0.0	0.0

Figure 54: Frequency of each indicator[1] of health by Infant Samples (Voegtly)



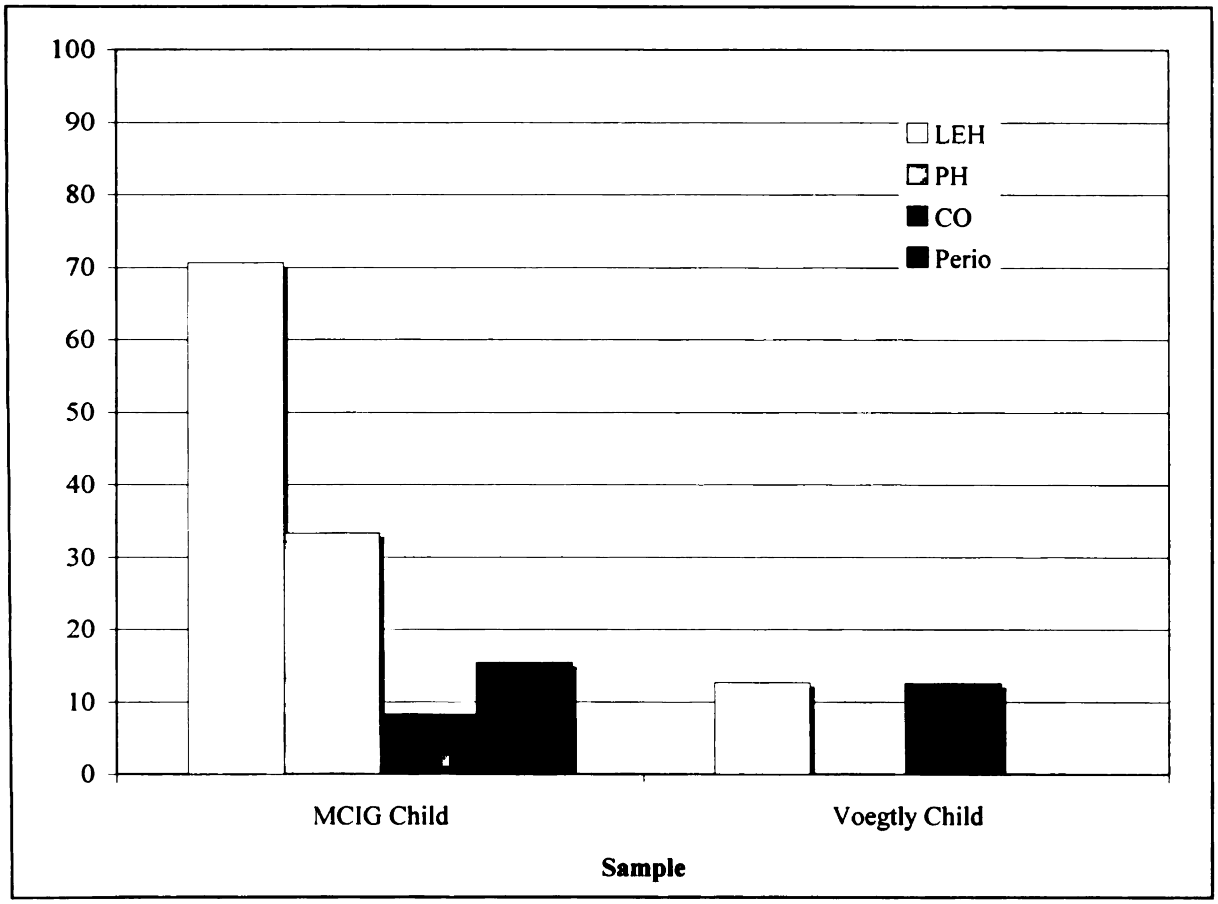
[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (Perio)

The child cohort for the MCIG cemetery exhibited a significantly higher prevalence rate for linear enamel hypoplasias when compared to the Voegtly sample. The child cohort for Voegtly showed a higher, although not significant, prevalence rate for cribra orbitalia. The following chi-square statistics were found for linear enamel hypoplasias ($\chi^2 = 30.278$, df=1) and cribra orbitalia ($\chi^2 = 0.150$, df=1). Tables 69 shows the frequency and prevalence rates for the child group from Voegtly. Figure 55 shows the frequency of each indicator of health in the samples.

Table 69: Frequency and Prevalence Rates for the Voegtly Child Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	14	96	110	12.7	127.3
Porotic Hyperostosis-Parietal	0	28	28	0.0	0.0
Cribra Orbitalia	4	28	32	12.5	125.0
Periostitis - Tibia	0	18	18	0.0	0.0

Figure 55: Frequency of each indicator[1] of health by Child Samples (Voegtly)



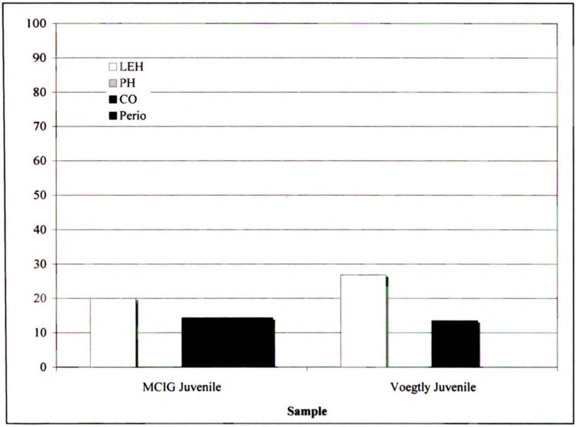
[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (Perio)

The juvenile cohort for Voegtly also showed a higher prevalence rate for linear enamel hypoplasias, while the MCIG juveniles showed a higher prevalence rate for cribra orbitalia. Although neither difference was found to be significant, the following chi-square statistics were generated: linear enamel hypoplasias ($\chi^2 = 0.109$, df=1) and cribra orbitalia ($\chi^2 = 0.003$, df=1). Table 70 shows the frequency and prevalence rates for the Voegtly cemetery. Figure 56 displays the frequency of the indicators of health for both MCIG and Voegtly juveniles.

Table 70: Frequency and Prevalence Rates for the Voegtly Juvenile Subadult Sample

Pathology	Present	Absent	Total Number	Frequency %	Prevalence /1000
LEH	15	41	56	26.8	267.9
Porotic Hyperostosis - Parietal	0	38	38	0.0	0.0
Cribra Orbitalia	5	32	37	13.5	135.1
Periostitis - Tibia	0	42	42	0.0	0.0

Figure 56: Frequency of each indicator[1] of health by Juvenile Samples (Voegtly)



[1] Linear enamel hypoplasias (LEH), Porotic hyperostosis in the parietal (PH), Cribra orbitalia (CO), and Periostitis on the tibia (Perio)

Common Odds Result for the MCIG and Voegtly Cemeteries

Only one common odds ratio estimate could be calculated for the between-group comparison between MCIG and Voegtly. The cribra orbitalia observed in each sample had an associated summary odds ratio of 0.310 (CI: 0.126-.761). The significant estimate shows that the prevalence of cribra orbitalia is overall lower in the MCIG sample than in the Voegtly sample.

Summary

This chapter provides a substantial amount of comparative results between the MCIG skeletal sample and both associated historical documentation and other comparative skeletal samples. Looking first at the comparison between the skeletal sample and the historical evidence, the skeletal sample from MCIG shows a lower prevalence of systemic infection than is listed in the burial registry. Ortner (2003) points out that, based on published prevalence rates, only a small percentage of individuals who have an infectious disease will exhibit skeletal evidence of the disease. As an example, the stated prevalence rate for those infected with tuberculosis who will exhibit skeletal pathologies is approximately 5%. Likewise, the stated prevalence rate for those infected with treponemal infections is 1-5% (Ortner 2003). Given this, the significant difference seen between the skeletal sample and the burial registry sample would be expected. In addition, the evidence for frequent epidemics in the City of Milwaukee, especially prior to 1920, increases the chance that those interred in the county grounds died from acute illnesses.

Historical comparisons of degenerative disease show evidence for a population still highly impacted by infectious disease, but one with steady declines in mortality rates and steady increases in the presence of degenerative diseases, such as cancer and heart disease. Particularly in the first quarter of the 20th century, the steady increase in degenerative diseases occurs while periodic epidemics are still a concern for the residents of the Milwaukee and its institutions.

The comparisons between the MCIG sample and other similar skeletal samples are what provide a better context for assessing the overall health of the MCIG sample. These between-group comparisons establish several trends among the samples. The most obvious one is that the prevalence of degenerative joint disease in significantly higher in the MCIG sample than that reported for either the Dunning sample or Voegtly sample. All samples, except for the Monroe County sample, provided substantial evidence for activity-based stressors. However, while factors such as taphonomy and researcher bias certainly play a role in observations of pathology, the MCIG sample still shows a high rate of activity-based stress in comparison. Coinciding with this observation, this indicator of health is predominantly the only indicator that was significantly higher in the MCIG sample.

Both the Dunning Poorhouse sample and the Monroe County sample showed some significantly higher prevalence rates in adult and subadult cohorts for indicators related to developmental, nutritional, and disease-related stress. The Voegtly cemetery showed significantly higher prevalence rates in nutritional stress as well, primarily in the subadult sample. The only age-specific cohort to show a significantly higher prevalence rate (other than for DJD) for the MCIG sample was the child cohort. The MCIG sample had a higher number of individuals in this age category provide evidence for linear enamel hypoplasias than either the Dunning sample or the Voegtly sample. This would suggest a higher level of developmental stress upon those aged 1-4 .9 years in the MCIG cemetery. As a note, while subadult femur lengths as compared to dental age are reported in Chapter 5 for the MCIG subadults, the other samples used for comparison in this dissertation did not have sufficient evidence available for a between-sample comparison. As such, this measure could not be used to further explore the impact of nutritional and developmental stress between subadult samples.

The differences seen in the age and sex demographics for each sample led to the use of common odds ratios to determine the patterns in the overall comparison between samples. The indicators of health used for these ratios were comprised of only those pathological conditions that were examined for both subadults and adults. In other words, neither specific diseases or DJD was used in the common odds calculations. While all calculated ratios were significant, the MCIG sample was the only sample not to show a significantly higher prevalence for any indicator of health examined. When looking at the overall sample, the Dunning, Monroe County, and Voegtly samples all exhibited a higher prevalence rate for cribra orbitalia. The Monroe County sample also showed a higher rate for porotic hyperostosis. The Dunning sample showed a higher rate for linear enamel hypoplasias. All indicators that were significant reflect developmental and, most likely, nutritional differences between the MCIG sample and the other samples. The one noticeable indicator that was not significant for any sample was the presence of tibial periostitis, a non-specific indicator of stress usually linked to disease-related stress.

The concluding chapter for this study will discuss the conclusions that can be drawn from the results of the comparative analysis. It will also address the contributions and limitations inherent in comparative skeletal studies.

PALEOPATHOLOGY AND PUBLIC HEALTH IN "AMERICA'S HEALTHIEST CITY": A COMPARATIVE STUDY OF HEALTH FROM THE MILWAUKEE COUNTY INSTITUTION GROUNDS CEMETERY

VOLUME II

By

Colleen F. Milligan

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Chapter 7 – Discussion and Conclusions

Discussion of Results

The expectations for the current study, as outlined in Chapter 3, addressed three areas: public health in American cities; defining health within the MCIG sample; and comparative studies. The results reported through the previous two chapters (Chapter 5: MCIG Results and Chapter 6: Comparative Results) provide information in all of these areas. The following sections specifically address the expectations for the current study in light of the results seen for both the MCIG sample and its comparison with other historical and skeletal samples.

Public Health in American Cities

The impact of infectious disease in American cities, particularly during the 19th and early 20th centuries, is apparent in historical studies. City records and reports, reports on institutional complexes, and burial records for all the samples used in this study highlight the presence of a number of different pathogens. Likewise, urban public health issues could not be separated from the political considerations in early urban America (Melosi 2000).

When looking specifically at the MCIG sample, the use of historical records for both the City of Milwaukee and the cemetery provides information on disease-specific mortality. It is evident from an analysis of the burial registry that the individuals buried on the Milwaukee County Institutional Grounds suffered from infectious disease, with roughly a third of all listed causes of death being attributed to infectious disease. The reminder of the listed causes of death are a mix of degenerative diseases, congenital diseases and defects, accidents, suicides, homicides, and stillborns. The results presented in Chapter 6 show that, when looking at temporal trends for associated causes of death, the burial registry does highlight a decline over time in regards to specific infectious pathogens. In particular the impact of diphtheria, typhoid fever, and small pox shows substantial declines by the time the cemetery was no longer in operation. The last 5 years of the burial registry (1921-1925) also shows a decrease in the number of deaths attributed to tuberculosis. Conversely, by 1925, the diseases for which a steady increase is seen are those associated with degenerative processes, like cancers and heart disease. The historical data for the other skeletal samples used in this study reveal that a similar decrease in infectious disease is not present.

The historical evidence seen with the City of Milwaukee shows a city at the beginning of an epidemiological shift from infectious disease to degenerative diseases. A report by the Milwaukee Health Department in 1931 (six years after the MCIG cemetery #2 ceased operations and a new cemetery for adults was opened on county grounds) shows this transition in greater detail. The report names 1930 as the "healthiest" year on record for the City of Milwaukee, owing in large part to the reduction in epidemics of influenza and pneumonia. It also details an important reduction in infant mortality, which is an area of the city's mortality not easily detected in the burial registry for the county grounds. The 1931 report also includes one of the first discussions in the city's reports about the need to address chronic diseases, such as cancer, diabetes and heart disease. As further evidence of Milwaukee's transitioning public health, comparative death rates for cities over 400,000 show the following rates for 1930 for three of this study's cities: Chicago 10.4, Pittsburgh 14.1, and Milwaukee 9.1 (*MHD 1931*).

Defining Health within the MCIG Sample

The variables selected to address the health of the MCIG sample and comparative samples relate to identifying developmental, nutritional, and disease-related stress. The skeletal analysis of the MCIG cemetery shows evidence for linear enamel hypoplasias, porotic hyperostosis, cribra orbitalia, tibial periostitis, specific infection, and degenerative processes. One expectation stated in Chapter 3 is that the MCIG sample would show higher levels of stress from activity-based and infectious stressors and less dietary-related stress. When looking at the prevalence rates presented for the MCIG sample in Chapter 5, the skeletal analysis differs in the trends seen between the subadult and adult samples.

MCIG Subadults

The MCIG subadult sample shows an overall low prevalence for infection (as identified by tibial periostitis) when compared with adult sample. This was expected as subadults, particularly those less than 1 year of age at death, are less likely to have developed a bony response to generally acute infections. The indicators of health that exhibit the highest prevalence rate among the subadults are linear enamel hypoplasias and porotic hyperostosis. The first indictor shows disruptions in growth during childhood. Its presence in the MCIG subadult sample could be related to a number of factors including malnutrition, infectious disease, and trauma. Regardless, hypoplasias observed in dental enamel provide evidence for the presence of systemic stress among the subadults.

Evidence of porotic hyperostosis and cribra orbitalia show that at least part of the systemic stress experienced by subadults in the MCIG cemetery may be related to nutritional stress. While both porotic hyperostosis and cribra orbitalia are often linked to anemias resulting in deficiencies of iron, recent studies of porotic hyperostosis have suggested that this pathological condition may be related to both dietary and disease stress (Ubelaker 1992; Walker *et al.* 2009).

When related to anemic conditions, Walker *et al.* (2009) suggest that a deficiency in vitamin B_{12} may be more likely the cause of porotic hyperostosis than deficiencies in iron. The vitamin deficiency may also be correlated to a decreased immune resistance to infection. Likewise, multiple deficiencies could be the cause of cribra orbitalia, including a deficiency in vitamin C (Walker *et al.* 2009). Additional skeletal evidence for deficiencies in vitamin C, associated with childhood scurvy, is not addressed in the present study. The presence of both of these indicators of health suggests that nutritional stress may have also decreased the immune response to infection. This conclusion would further support the low prevalence of a bony response to infection within the subadult sample. As a note, skeletal studies will often show more evidence for cribra orbitalia than porotic hyperostosis (Steckel *et al.* 2002b). The opposite trend is found in the both the adults and subadults within the MCIG sample where porotic hyperostosis is more prevalence than cribra orbitalia.

Differences seen between age categories for the subadults were limited to two indicators of health, linear enamel hypoplasias and periostitis. Overall, the child cohort for the MCIG sample exhibits a significantly higher prevalence for linear enamel hypoplasias than either the infant or juvenile groups. The frequency for this group (70.6%) suggests that those dying between the ages of 1 and 5 years where more likely to show evidence for systemic stress. While all age groups may have been equally exposed to infectious disease, especially acute pathogens, the child group exhibits the highest prevalence for tibial periostitis among the subadult age groups. The juvenile group also shows a higher rate of tibial periostitis than the infant group, but only the difference between the child and infant groups was significant. Again, the infant group is inherently less likely to exhibit a bony response to infection due to the short duration of their lives. The evidence suggests that the child cohort (1-4.9 years) was the most highly stressed group among the subadults.

MCIG Adults

The adult sample for MCIG shows the highest prevalence for linear enamel hypoplasias, non-specific infection, and degenerative processes. Although porotic hyperostosis and cribra orbitalia are present in the sample, the prevalence for these indicators is the lowest out of all measures of health that were observed for the adults. Only one individual, out of the 20 adults with parietal porotic hyperostosis, exhibited a mixed reaction, meaning the pathology presented evidence of both an active and healed response. The rest of the sample showed a healed response of porotic hyperostosis suggesting that, for most adults, the exposure to stressors causing porotic hyperostosis occurred earlier in life. In contrast, the responses of cribra orbitalia were evenly divided between a healed response and a mixed response. The age-related differences seen with these divided responses will be discussed shortly.

The one individual who presented a mixed reaction for porotic hyperostosis was Burial 5074, a middle-aged adult male. This individual also presented evidence for linear enamel hypoplasias and a systemic infection involving periostitis on both tibiae and both fibula. As will be discussed next, the presence of linear enamel hypoplasias suggest systemic developmental stress during childhood as does the healed porotic hyperostosis response. The active porotic hyperostosis and periosteal infection may be indicative of disease-related stress in adulthood.

The presence of linear enamel hypoplasias in the adults shows the impact of systemic stressors during early childhood development. While not directly tied to adult health, the presence of this growth disruption may indicate a reduced immune capacity in response to stressors encountered as an adult (Boldsen 2007). This observation is supported by the fact that evidence of systemic infection is also higher in the adult sample with regard to other indictors of health. The only indicator higher than either of these is the prevalence of degenerative changes.

The higher prevalence of systemic infection, although mostly non-specific in nature, provides evidence for the impact of infectious disease among the adults interred on the county grounds. In addition, six adults were found with pathology suggestive of tuberculosis, and one adult exhibited evidence of a possible treponemal infection. These observations support evidence from the Register of Burials for the cemetery for the presence of both tuberculosis and syphilis within the City of Milwaukee.

The impact of degenerative changes in the form of degenerative joint disease suggests that adults of all ages experienced activity-based stress during their lifetime, a measure of stress that would not be present in the burial record. Degeneration of the joints is common in aging populations, but its prevalence in the young and middle-aged adults in the MCIG sample suggests that the quality of life for all adults may have been reduced by the constant presence of physical stress.

One expectation outlined in Chapter 3 that was not met was that the presence and variability of all indicators of health would be greater in the adult male sample than either the adult females or subadult samples. This expectation was based on the fact that the MCIG sample likely includes a large number of middle-aged immigrant or industrial workers, exposed to a significant amount of stress. In contrast, historical evidence for relief efforts aimed at women and children, particularly in the beginning of the 20th century, was expected to play a role in reduced exposure to certain stressors in the adult female and subadult groups. The results show very little differences between the adult male and adult female samples. Of the differences in prevalence seen, none are significant between the adult sexes. Adult males do show a higher prevalence for degenerative joint disease and linear enamel hypoplasias, although again neither are significantly different from adult females. The adult female sample and subadult sample show a higher prevalence of porotic hyperostosis and cribra orbitalia. However, while the subadult sample shows a lower prevalence for non-specific infection, the adult sexes exhibit similar rates of non-specific and systemic infection. The prevalence of skeletal evidence for tuberculosis, observed in both sexes, was also not significant. The similarity in the prevalence for non-specific and specific infectious disease does meet the expectation that exposure to infectious disease would be represented throughout the sample. Overall, non-significant results between the sexes are unexpected.

In contrast, several significant differences were seen between adult age categories. These differences generally separate the young adults from either the middle-aged or old adults. While the prevalence for linear enamel hypoplasias varies little between groups, the young adults exhibit a higher prevalence of porotic hyperostosis and cribra orbitalia when compared to the other age groups. In particular, the difference seen for cribra orbitalia is significant. When looking closer at the observations of cribra orbitalia, the scored expressions of this pathological condition are split between healed reactions (reactions showing evidence of remodeling) and mixed reactions with both active and healed portions. Of the six adults scored for cribra orbitalia, three are scored with healed reactions. They consist of one middle-aged male, one old male, and one old female. The remaining three exhibit a mixed reaction and consist of one middle-aged male, one young male, and one young female. All active reactions are primarily restricted to young adults, while the majority of healed reactions are old adults. This observation provides evidence for possible nutritional or disease-related stress around the time of death for the young adults. The reactions seen in the older adults suggest stress experienced earlier in life.

Evidence for infection, both non-specific and specific, and degenerative changes were found to be significantly higher in the middle-aged and old adults when compared to the young adults. The differences seen in degenerative changes are expected, as the trend evidenced in the MCIG adults is that older adults exhibit more degenerative joint disease than younger adults. With regard to specific diseases, no young adults show evidence for tuberculosis in the vertebrae, although one individual does show potential evidence for tuberculosis in the ribs. The other five individuals presenting evidence for tuberculosis are middle-aged or old adults. As a note, the one case of a possible treponemal infection was seen in a young adult. It is possible that, while all adult age cohorts exhibit evidence of systemic stress in the form of linear enamel hypoplasias, the significantly higher prevalence for cribra orbitalia may suggest that young adults interred on county grounds were more susceptible to acute illnesses. The presence of a bony response to infection shows at least some evidence of a sustained defense against an infectious pathogen. The middle-aged and old adults may have had the best immunity to the disease (Wood *et al.* 1992; Wilbur *et al.* 2008).

Wilbur *et al.* (2008) provide an alternative hypothesis about the connection between diet and tuberculosis. The authors look at two types of nutritional deficiencies: protein deficiency and iron deficiency. The article presents evidence that a diet with inadequate protein decreases the antimicrobial activity in regards to containing the tuberculosis bacilli, allowing it to spread outside of the lungs. The authors suggest that the dissemination of the bacilli is likely rapid and any skeletal manifestation would be limited to the ribs (Wilbur *et al.* 2008). On the other hand, diets with sufficient iron may actually promote mycobacterial (tuberculosis bacilli) growth. A slight iron deficiency might actually protect the host against an active infection (Wilbur *et al.* 2008). As noted earlier, Walker *et al.* (2009) suggest that porotic hyperostosis may be the result of a deficiency in vitamin B_{12}, a vitamin found in food from animal sources such as milk, fish, and meat. A vitamin B_{12} deficiency represents a deficiency in protein. Cribra orbitalia is most commonly associated with a deficiency in iron.

In the context of the MCIG sample, the overall adult sample exhibits more evidence for porotic hyperostosis than cribra orbitalia. Although the adults show more evidence for porotic hyperostosis, almost all observations of porotic hyperostosis show a healed response, suggesting a deficiency in the past, but not at the time of death. In contrast, the cribra orbitalia reactions are largely active in young adults and show signs of healing in older adults. All adult age groups exhibit possible evidence for a protein deficiency during the course of their lifetime, while only the young adults present evidence of a possible current iron deficiency. Wilbur *et al.* (2008) suggest that in situations where there is sufficient protein and insufficient iron, individuals are likely to exhibit linear enamel hypoplasias, show evidence for porotic hyperostosis (in this case referring to cribra orbitalia), offer the potential for rib lesions, and may exhibit vertebral collapse as a result of disease involvement in the vertebrae. The one young adult presenting evidence of a mycobacterium infection showed involvement of the ribs only. The middle-aged and old adults in the MCIG sample may reflect a diet with sufficient protein and iron, setting the stage for an increased antimicrobial response (immune response) with an associated increase in mycobacterial growth. In this case, these individuals would be more susceptible to bone involvement in response to the tuberculosis pathogen.

Comparative Studies

As stated in Chapter 3, the expectation established for the comparative studies was that the MCIG sample would reflect a lower rate of identifiable pathogens and increased pathology reflecting morbidity and survivability. This expectation was, at least in part, due to fact that the MCIG sample represented a time period directly following that of the comparative samples. This time period is one in which cities across America increased their efforts towards public health reform (Duffy 1978). The overall assessment from the between-group comparisons shows that, when indictors of health were present, the MCIG sample differs significantly from all comparative samples in regards to developmental and nutritional stress.

As discussed in the previous chapter, the common odds ratio was used to compare four indicators of health (linear enamel hypoplasias, porotic hyperostosis, cribra orbitalia, and tibial periostitis) between the MCIG sample and each of the comparative skeletal samples. The common odds ratio summarizes the prevalence of a disease or indicator of health for a sample by combining the age or sex-specific prevalence rates. This negates the added effect of differences in population structure between samples. The four indicators of health assessed were the ones for which both a prevalence rate for the adults and the subadults could be combined. In the case of the samples used in this study, this was particularly important because the subadult and adult samples do not necessarily represent the same populations for the MCIG, Dunning, and Monroe County cemeteries.

The results of the common odds ratio show that every comparative sample has a significantly higher prevalence rate for cribra orbitalia than the MCIG sample. Overall, the MCIG sample most likely exhibits less evidence for a nutritional deficiency in iron or vitamin C. Both the Dunning and the Monroe County samples provide additional evidence for increased systemic stress. The prevalence of linear enamel hypoplasias was significantly higher in the Dunning sample. The prevalence of porotic hyperostosis was significantly higher in Monroe County. All of these observations are in relation to a comparison with the MCIG sample. Cross-comparisons, such as those between Dunning and Monroe County or Monroe County and Voegtly, were not examined in the current study.

Looking closer at the presence of cribra orbitalia, the Dunning sample shows that most observations of this pathological condition in the subadults were active responses. Only one juvenile presented evidence of healing. This suggests that the Dunning subadults were nutritionally stressed at or around the time of death. All observations in the adult sample for Dunning show healed responses. The adults entering the Dunning Poorhouse experienced nutritional stress earlier in life. In contrast, the MCIG young adults displayed a mixed reaction suggesting that the stress encountered was present around the time of death. The Voegtly sample shows that the only active responses were found in the child cohort similar to the Dunning sample. Healed responses were observed in both subadults and young adults. This suggests that nutritional or disease-related stress was present during early development for the Voegtly sample. It may also present evidence for a reduced immune response among these groups and hence a higher risk of an early death. However, no observations of porotic hyperostosis were noted for the Voegtly sample, so while there is evidence of a possible deficiency in iron, there is an absence of evidence for other possible nutritional deficiencies.

The Monroe County report, while scoring for cribra orbitalia, did not score the pathology as having an active or healed response. It also did not score the presence or absence of healing for porotic hyperostosis. However, Higgins and Sirianni (1995) report that the most stressed groups in the almshouse population were women and children. In particular, the authors discuss historical evidence for a high level of nutritional stress experienced by these groups. This is reflected in the significant differences seen in cribra orbitalia and porotic hyperostosis between the MCIG sample and the Monroe County sample, including significant chi-square results between the samples' females and subadults.

Ubelaker and Jones (*Human Remains from Voegtly Cemetery* 2003) point to problems with sanitation, inadequate nutrition, and infectious disease in the Voegtly community and surrounding area. The presence of nutritional stress is evidenced by the significantly higher prevalence for cribra orbitalia in comparison to the MCIG sample. When looking at the available historical evidence for infectious disease, the Voegtly sample appears to be mostly impacted by epidemics of cholera, typhoid fever, and yellow fever (*Human Remains from Voegtly Cemetery* 2003), none of which commonly leave skeletal evidence. The community was also exposed to tuberculosis.

The presence of non-specific indictors of infection, observed as tibial periostitis, was not significantly different between the MCIG sample and any of the comparative samples. This suggests that all samples were exposed to infectious disease and exhibited some skeletal response to infection. However, when looking at a specific pathogen, tuberculosis, chi-square statistics showed a significantly higher prevalence for tuberculosis in the vertebrae of Monroe County adults. There were no significant differences between the expression of tuberculosis in the MCIG adults and the Voegtly adults. The Dunning sample showed only one individual, a juvenile, with possible evidence of tuberculosis.

As discussed earlier, Wilbur *et al* (2008) suggest a connection between deficiencies in iron and protein and skeletal expressions of tuberculosis. Considered separately, the Dunning sample shows a significantly higher prevalence for cribra orbitalia, a possible iron deficiency, but almost no evidence for tuberculosis. The deficiency in iron, in this case, may have offered limited protected against mycobacterial growth and hence active tuberculosis (Wilbur *et al.* 2008). The Monroe County sample shows significantly more cribra orbitalia and porotic hyperostosis suggesting possible deficiencies in both iron and protein. It also shows a higher prevalence for skeletal manifestation of tuberculosis. The expectations outlined by Wilbur *et al.* (2008) for deficiencies in iron and protein are high levels of linear enamel hypoplasias (which is seen), expressions of cribra orbitalia, and the possibility of a bony response to infection.

The Voegtly sample offers only a significantly higher prevalence for cribra orbitalia and no evidence of porotic hyperostosis. The article by Wilbur *et al.* (2008) suggests that sufficient protein and inadequate iron in a diet offers less potential for skeletal evidence of tuberculosis.

The one area where the MCIG sample did show significantly higher prevalence rate was in the presence of degenerative joint disease in adults. Monroe County did not score for this pathological condition and so no comparison could be made between the Monroe County sample and the MCIG sample. DJD was present in both the Dunning and Voegtly samples. The MCIG sample shows a greater impact of activity-based stressors, a degenerative change, than the other samples. The particular stressor is often related to the quality of life for an individual. Nutritional, developmental, and infectious stressors are discussed below, which are more closely linked to the risk of death for individuals.

Taken together, all samples considered show populations under stress. However, the overall MCIG sample shows less stress due to nutritional and developmental stressors than any of the other samples considered. Those interred on county grounds experienced comparably less stress as a result of diet and possibly non-specific disease processes (as cribra orbitalia and porotic hyperostosis can also result from infectious disease).

It also shows less evidence for tuberculosis than the Monroe County sample. When looking at disease-specific mortality rates, the presence of a skeletal response to infectious disease does not necessarily mean that the sample or individual in question is less healthy than those that exhibit the absence of evidence for the disease (Wood *et al.* 1992). In the case of the between-sample comparison for tuberculosis, a conclusion about the relative impact of tuberculosis on each sample is aided by available historical evidence. Disease-specific mortality rates are available for both samples. For the Monroe County Poorhouse, tuberculosis was the leading cause of death, with 28.9% of poorhouse deaths attributed to this disease. In contrast, tuberculosis is listed as the primary cause of death for 12.3% of those interred on county grounds. This suggests that while both samples were exposed to high enough levels of stress to elicit a skeletal response, the MCIG burial sample's rate of mortality from tuberculosis was still comparably lower. If we assume that the risk of exposure was similar for both samples, then the rate of those dying from tuberculosis is greater in the Monroe County burial sample.

A later study of the Monroe County Poorhouse by Higgins *et al.* (2002) generates a health index score in comparison with other North American skeletal samples. The authors find the relative health of the residents of the Monroe County Poorhouse was poor. While the current study cannot say that the MCIG sample was "healthy", the between-group comparisons do provide evidence that the MCIG sample was "healthier" than the samples considered from an earlier timeframe. The results suggest that the advances in public health reform in the time period represented by the MCIG cemetery #2 did affect, at least in part, the environmental context and exposure to stress for those interred on county grounds.

Limitations of Comparative Skeletal Studies

One additional topic to be discussed briefly is the limitation inherent in comparative skeletal studies. The primary way in which skeletal studies differ is in how biological variables such as age, sex, and paleopathology are categorized and scored. In general, the current study found that the methods used to assess these variables were largely consistent between samples. There was general agreement as to what constituted a certain pathological condition or what skeletal features should be used to assess age and sex. However, each study differed slightly in how these observations were scored.

For example, porotic hyperostosis in the MCIG sample was scored as present or absent based on individual cranial bones affected and the total number of individuals with those bones present. Specifics on the type of reaction seen included severity scores based on discernible porosity. Evidence of an active, healed, or mixed response was also noted. The Dunning sample also scored this indicator of health by individual cranial bones affected, but severity scores ranged from mild to moderate to severe. Evidence for healing or active responses were similar to MCIG. Monroe County scored presence by the whole crania instead of individual bones. Severity scores ranged from light to medium to severe, and no notes were included on the activity of the responses. The Voegtly cemetery data collection, which was based on *Standards* (1994) like the MCIG sample, did not have any reported observations of porotic hyperostosis.

The resulting impact of these differences is that each sample must be considered separately as some, but not all, measures of health would be present in each sample. As an example, comparisons between the Dunning sample and the MCIG sample, in regards to porotic hyperostosis, discussed prevalence in the parietal bones. The comparison with the Monroe County sample could not single out a specific cranial bone, although observations of cribra orbitalia were separated from porotic hyperostosis.

Another primary concern in comparable skeletal studies is the medium in which the data for another sample is available. The most direct comparative analysis for the current study was between the MCIG sample and the Dunning sample. With both, the access to raw data from the skeletal collections allowed for the most freedom in how the comparative analysis was set-up. The Monroe County and the Voegtly samples both included partial inventories and notes of scored pathology, but the comparative analysis relied on what variables could be extracted within the framework already established for the principal MCIG investigation.

One note of importance is that the Monroe County sample has actually two reports. The first is the principal analysis by Lanphear and colleagues used in this study. The second is a later study, conducted before the remains were re-interred, by Higgins, Sirianni, and colleagues. The later study presents different prevalence rates for many of the indicators of health used in this study. For example, the frequency of tibial periostitis in the subadult sample is reported by Lanphear (1988) as 48.9%, while the frequency reported by Higgins *et al.* (2002) is 19%. Although this difference is still significantly different between the MCIG subadults and the Monroe County subadults, there is a wide disparity in observations. The later study is published in several edited volumes. The most recent is part of Steckel and Rose's project to create health index scores for the comparison of relative health across samples. While the categorization of the data is more similar to the MCIG sample, the format of the data presentation did not offer enough flexibility for a comparison with the MCIG sample. In particular, the results do not address adult age-related differences and no inventory is present to extract such information separately. It also does not address specific infectious diseases within the sample.

Variation in preservation and the availability of certain additional techniques, such as molecular analysis, are among a number of factors that make complete standardization of research methods difficult. However, the availability of collection data in published form provides a more flexible context for additional studies. Given the limited amount of information recovered from any skeletal sample, the ability to use comparative data strengthens the conclusions drawn for any skeletal sample.

Past Health and Modern Problems

In 2009, the WHO reported that incidence rates of tuberculosis were continuing to decline worldwide (*World Health Statistics* 2009). The decline of one of the most virulent infectious diseases in modern times is the result of a global effort to improve health. In September 2000, the 191 member states of the United Nations agreed upon the UN Millennium Declaration. This declaration set out eight target goals for 2015 (*World Health Statistics* 2009):

1) to eradicate extreme poverty and hunger
2) to achieve universal primary education
3) to promote gender equality and empower women
4) to reduce child mortality
5) to improve maternal health
6) to combat HIV/AIDS, malaria, and other diseases
7) to ensure environmental sustainability
8) to develop a global partnership for development

These goals, and the measures outlined to meet the goals, represent one of the most aggressive and expansive campaigns to improve global health. They highlight the importance given to such initiatives. They also echo concerns expressed by past generations, particularly in regards to the prevalence of disease in world populations.

In the fall of 1918, the City of Milwaukee issued ordinances against gathering in public spaces in order to combat the influenza epidemic sweeping the nation. Schools and movie theaters closed. Bars and restaurants had restrictions on how many people could congregate at a time. Restrictions were placed on the number of passengers per streetcar

(Leavitt 1982). This was the first time the city mandated such measures and it was rewarded with one of the lowest mortality rates from influenza and one of the shortest durations for the epidemic in the country.

The policies started almost a century ago were used again in the fall of 2009 when a sudden increase in the HINI virus stretched the ability of American cities to control the infection. Like their early 20th century predecessors, Milwaukee Health Department officials closely monitored the incidence rate for the virus in the city. Their response was one of the first reported in national news forums. The *Milwaukee Journal-Sentinel* chronicled the closing of the city's public schools to slow the spread of the disease. Maintenance personnel cleaned desks, railings, sinks, carpets, books, and everything else that could pass along the pathogen to students. Public information was disseminated, targeting specifically high-risk groups, on the importance of vaccination. Clinics for the vaccination of the general public were set-up as batches of the vaccine became available (Hetzner 2009).

The policies developed during the late 19th and early 20th century took years to increase in effectiveness, but once established, have been the policies that the city still maintains today in response to infectious threats. While this connection of past health and modern problems provides an interesting insight into continued public health efforts, a study released by the Robert Wood Johnson Foundation and the University of Wisconsin Population Health Institute shows how much has changed in the intervening years.

Called the MATCH project (Mobilizing Action Toward Community Health), the project created county health rankings for each state in the United States. It measures four types of health factors: self-reported health behaviors; social and economic factors

including education, employment, and income; access and quality of clinical care; and the impact of the physical environment relating to environmental quality (*County Health Rankings*). Several of the areas address concern for degenerative diseases, mainly through measuring the impact of diet and exercise on morbidity rates. None of the measures directly address infectious disease or its potential impact on a county's residents.

Under this system for addressing population health, Milwaukee County was ranked 71 out of 72 for Wisconsin's counties for 2010. Its worst component scores were in the areas of physical environment (air pollution and access to healthy foods), health behaviors (smoking, obesity, teen pregnancies, etc), and morbidity (self-reported assessment of personal health). In each of these areas, Milwaukee County showed the lowest scores in the state. The counties bordering to the north and west received the 1st, 3rd, and 4th place in the rankings respectively showing a dramatic increase in health within Milwaukee's suburbs. Overall, the State of Wisconsin currently ranks 12th in *America's Health Rankings* for 2009. While no longer considered "America's healthiest", the role of public health reform in the county of Milwaukee has not diminished over the years. How health and health concerns are addressed continues to play an important part in the lives of the descendents of one of the most successful public health movements in American urban history.

APPENDIX A

MCIG Adult and Subadult Data Summary

This appendix provides an overall summary of the adult and subadult samples used in this dissertation. The data was collected by researchers, including this author, during the principal investigation of the MCIG skeletal remains at Marquette University under Dr. Norman Sullivan, and is used with permission of the principal investigator. The original data was collected following *Standards* (1994). The scoring system used to re-categorize the data for this study is below and also follows the guidelines set forth in *Standards* (1994). Descriptions of the data used and how it is categorized can be found in Chapter 4. The following sections outline the scoring used to categorize the original data, a table key for both the adult and subadult summary tables, and the tables for the adult and subadult samples. The scoring system used for both samples is presented first, followed by the adult table key and summary table. The table key and summary of the subadults follows the adult summary table. Each table presents summary data that was used to identify and examine the primary indicators of health used in this study.

MCIG Adult and Subadult Scoring

Linear Enamel Hypoplasias:
Location:
1. Maxillary central incisors
2. Maxillary lateral incisors
3. Maxillary canines
4. Mandibular central incisors
5. Mandibular lateral incisors
6. Mandibular canines

Type:
1. Linear horizontal grooves
2. Linear vertical grooves
3. Linear horizontal pits
4. Nonlinear array of pits
5. Single pits

Porotic Hyperostosis:
Location:
1. Frontal
2. Left Parietal
3. Right Parietal

4. Both Parietals
5. Occipital

Severity:
1. Barely discernible porosity
2. Porosity only
3. Porosity with coalescing pores
4. Coalescing pores with expansive thickening

Healing:
1. Active at the time of death
2. Healed
3. Mixed active and healed

Cribra Orbitalia:
Location:
1. Left eye orbit
2. Right eye orbit
3. Both orbits

Severity:
5. Barely discernible porosity
6. Porosity only
7. Porosity with coalescing pores
8. Coalescing pores with expansive thickening

Healing:
4. Active at the time of death
5. Healed
6. Mixed active and healed

Periostitis:
Location:
1. Left femur
2. Right femur
3. Both femurs
4. Left tibia
5. Right tibia
6. Both tibiae
7. Left fibula
8. Right fibula
9. Both fibulas

10. Left humerus
11. Right humerus
12. Both humeri
13. Left radius
14. Right radius
15. Both radii
16. Left ulna
17. Right ulna
18. Both ulnae
19. Left clavicle
20. Right clavicle
21. Both clavicles
22. Ribs

Reaction:

1. Reactive woven bone
2. Sclerotic reaction
3. Both woven and sclerotic

Extent:

1. <1/3
2. 1/3 – 2/3
3. >2/3

Infection:

Location:

1. Cranial
2. Upper long bones
3. Lower long bones
4. Hands and feet
5. Pelvis
6. Vertebrae
7. Ribs

Pathology Categories:

1. Specific – tuberculosis
2. Specific – treponemal infection
3. Nonspecific - osteomyelitis
4. Nonspecific – all lower limbs affected

Degenerative Joint Disease:

Location:

1. Left shoulder
2. Right shoulder
3. Left elbow
4. Right elbow
5. Left hip
6. Right hip
7. Left knee
8. Right knee
9. Left wrist/hand
10. Right wrist/hand
11. Left ankle/foot
12. Right ankle/foot

Degree:

1. Barely discernible/slight lipping
2. Sharp ridge/moderate lipping
3. Extensive spicules/severe lipping
4. Destruction of joint surface/ankylosis

Degenerative Vertebral Changes:

Location:

1. Cervical
2. Thoracic
3. Lumbar

Type:

1. Osteophytes
2. Enthesophytes

Degree:

1. Barely discernible/slight lipping
2. Elevated ring/moderate expression
3. Extensive spicules/severe expression
4. Fusion present

MCIG Adult Table Key

Burial #:	Excavated burial lot number
Age/Sex:	1 – Young female 2 – Middle-age female 3 – Old female 4 – Young male 5 – Middle-aged male 6 – Old male 7 – Young ambiguous sex 8 – Middle-age ambiguous sex 9 – Old ambiguous sex 10 – Unknown age/sex
AT:	Anterior teeth X = Incomplete, absent, or unable to be used for analysis
PAR:	Parietal X = Incomplete, absent, or unable to be used for analysis
ORB:	Eye orbit X = Incomplete, absent, or unable to be used for analysis
RIB:	Rib X = Incomplete, absent, or unable to be used for analysis
VER:	Vertebrae X = Incomplete, absent, or unable to be used for analysis
FEM:	Femur X = Incomplete, absent, or unable to be used for analysis
TIB:	Tibia X = Incomplete, absent, or unable to be used for analysis
LEH:	Linear enamel hypoplasia LEH = present
PH:	Porotic hyperostosis PH = present
CO:	Cribra orbitalia CO = present

TP:	Tibial periostitis TP = present
TB:	Tuberculosis TB = evidence for tuberculosis present
TREP:	Treponemal infection TREP = evidence for treponemal infection present
DJD:	Degenerative joint disease DJD = present

Table 71, MCIG Adult Summary, follows this page.

Table 71: MCIG Adult Summary

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
1001	7		X	X	X	X									
1002	7														
1004	6	X			X	X									DJD
1009	5									PH					DJD
1010	4					X									
1011	2														DJD
1012	5	X													DJD
1013	5														DJD
1014	3														
1015	4														DJD
1016	5	X										TP			DJD
1017	5	X													DJD
1021	5	X													DJD
1023	5	X			X							TP			DJD
1024	6	X	X	X											DJD
1025	10	X	X	X	X		X	X							
1027	4	X	X	X			X	X							DJD
1030	5						X	X							DJD
1031	5		X	X				X							DJD
1034	10	X													DJD
1035	4				X										
1037	7														DJD
1040	4	X	X	X	X	X	X	X							DJD
1044	5														DJD
1046	8	X													DJD
2003	4												TB		DJD
2005	5														DJD
2006	4														DJD
2007	4														DJD
2008	1			X											DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
2009	1										CO				
2010	2	X	X	X											DJD
2012	5	X	X	X	X	X									DJD
2013	4	X	X	X	X	X									DJD
2014	5	X	X	X	X										DJD
2015	5	X	X	X	X	X						TP			DJD
2018	5	X					X	X							DJD
2019	5	X	X	X	X	X		X							
2020	6	X						X							DJD
2021	5														DJD
2022	6	X													DJD
2023	5	X	X	X											DJD
2025	5	X			X	X									DJD
2026	4	X													DJD
2027	5									PH					DJD
2031	5	X	X	X	X	X	X	X							
2033	5	X								PH					DJD
2034	5	X			X	X	X								
2035	1	X			X	X									DJD
2036	10	X	X	X	X	X	X								
2038	4	X				X									
2039	5	X													DJD
2040	5	X				X									DJD
2041	5	X													DJD
2042	5	X													DJD
2044	5	X	X	X											DJD
2045	6	X	X	X											DJD
2046	5	X			X										DJD
2047	6	X			X										DJD
2048	5	X													DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
2049	5	X			X										DJD
2050	2	X													DJD
2051	4	X													DJD
2052	4	X													DJD
2053	8	X	X	X				X							DJD
2054	4	X						X							
2055	4	X								PH					DJD
2056	6	X			X			X							DJD
2061	4	X								PH					DJD
2062	5	X										TP			DJD
2064	10	X	X	X	X	X	X	X							
2065	5	X													DJD
2066	5	X	X	X											DJD
2067	2	X													DJD
2068	5														DJD
2070	4	X		X								TP			DJD
2071	4	X			X	X									DJD
2072	5	X													DJD
2073	6	X				X									DJD
2074	5	X													DJD
2075	4	X									CO				DJD
2076	6	X		X	X										DJD
2077	5	X	X	X								TP			DJD
2081	5	X			X	X				PH	CO				DJD
2087	4	X	X		X						CO				DJD
2088	6	X													DJD
2093	5	X													DJD
2095	5	X													DJD
2097	10	X	X	X	X	X	X								
2114	10	X	X	X	X	X									DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
2123	10	X	X	X	X		X	X							
2127	10	X	X	X	X		X	X							
2128	10	X	X	X	X	X		X							
2129	2	X			X	X	X	X							DJD
2135	10	X	X	X			X	X							
2137	4	X					X	X		PH					DJD
2139	2	X					X	X							DJD
3026	5	X				X									DJD
3028	4	X			X										DJD
3029	5	X													DJD
3031	8	X			X										DJD
3032	6	X								PH					DJD
3033	8	X													DJD
3035	5	X			X			X							DJD
3036	5								LEH						DJD
3037	5	X						X							DJD
3038	5								LEH						DJD
3039	5												TB		DJD
3040	5	X	X	X			X	X							
3041	5								LEH						DJD
3042	5	X										TP			DJD
3043	5	X													DJD
3044	5	X													DJD
3045	5	X			X	X									DJD
3047	5				X				LEH						DJD
3048	6	X													DJD
3049	5	X													DJD
3050	2	X													DJD
3051	5	X				X									DJD
3052	10	X			X	X									

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
3054	5	X			X										DJD
3055	7								LEH						
3056	5				X	X		X							
3057	3	X			X	X									
3058	5	X													DJD
3059	9	X													
3060	5								LEH						DJD
3061	5									PH					DJD
3062	5				X	X			LEH						DJD
3063	5								LEH	PH					DJD
3064	5	X										TP			DJD
3065	5														DJD
3066	5								LEH	PH					DJD
3067	6		X	X	X	X	X	X	LEH						
3068	5														DJD
3069	5	X													DJD
3070	5								LEH						DJD
3071	5								LEH						DJD
3073	5								LEH						DJD
3074	6	X													DJD
5001	6			X	X							TP			DJD
5002	5	X	X	X	X	X									DJD
5005	6	X													DJD
5007	5	X			X		X	X							DJD
5009	1	X													DJD
5010	5	X	X	X	X										DJD
5012	5	X	X	X											
5013	5	X			X		X	X							
5014	6	X													DJD
5015	4	X													DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
5016	5	X													DJD
5017	6	X													DJD
5018	5	X													DJD
5019	6	X													DJD
5020	5	X				X									
5026	6	X													DJD
5027	5								LEH						DJD
5028	3														DJD
5029	4	X													DJD
5031	3	X													DJD
5032	5	X													DJD
5034	1	X													DJD
5035	2	X										TP	TB		
5036	5														DJD
5037	4	X													DJD
5039	5														DJD
5040	5														DJD
5041	5	X													DJD
5043	6	X													DJD
5047	5	X													DJD
5048	2														DJD
5049	5														DJD
5050	1	X	X	X											DJD
5052	5	X													DJD
5055	2	X	X	X											DJD
5056	5	X													DJD
5057	5	X			X					PH					DJD
5058	4	X										TP			DJD
5060	5														DJD
5061	5	X										TP			DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
5062	5	X													DJD
5063	5	X													DJD
5066	3	X													DJD
5067	5	X													DJD
5068	6	X													DJD
5069	6	X													DJD
5070	5	X													DJD
5071	5	X													DJD
5073	5	X													DJD
5074	5									PH		TP			DJD
5075	5														DJD
5076	6	X													DJD
5077	5	X													DJD
5079	5								LEH						DJD
5087	5	X													DJD
5089	5														DJD
5090	5				X				LEH						DJD
5091	4														DJD
5092	5	X	X	X	X	X	X	X							
5093	5	X			X										DJD
5094	6	X													DJD
5095	5	X	X	X	X	X									DJD
5096	5	X	X	X											DJD
5097	5														DJD
5098	5	X													DJD
5099	6	X			X					PH	CO				DJD
5100	5	X			X										DJD
5101	4					X									DJD
5102	6	X													DJD
5103	6								LEH						DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
5104	6	X													DJD
5105	1								LEH						
5106	6	X													DJD
5107	5				X	X			LEH						DJD
5108	5				X										DJD
5109	5	X			X										DJD
5110	5	X													DJD
5111	8	X													DJD
5112	5	X													DJD
5113	5	X													DJD
5114	5	X													DJD
5116	5				X				LEH						DJD
5117	5	X													DJD
5118	5	X			X										DJD
5119	6	X			X										DJD
5120	5								LEH						
5121	8								LEH						DJD
5122	5														DJD
5123	9	X													DJD
5124	6														DJD
5125	6								LEH						DJD
5127	6	X										TP			DJD
5128	2								LEH						DJD
5129	6	X								PH					DJD
5130	5	X													DJD
5131	6	X													DJD
5132	5								LEH						DJD
5133	6				X				LEH						DJD
5134	5	X				X									DJD
5135	5	X													DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
5136	5	X													DJD
5137	5	X		X											DJD
5138	6	X													DJD
5139	8								LEH						DJD
5140	6	X													DJD
5141	5														DJD
5142	9	X													
5143	8	X													DJD
5144	5									PH					DJD
5145	4	X													DJD
5146	5								LEH						DJD
5147	6	X													DJD
5148	5								LEH						DJD
5149	6	X			X										
5150	5								LEH						DJD
5152	5								LEH						DJD
5153	4								LEH						DJD
5155	5														DJD
5156	5	X	X	X	X							TP			DJD
5162	5														DJD
5165	5				X			X							DJD
5166	5	X			X	X		X							DJD
5168	4	X	X	X			X	X							DJD
5173	10	X	X	X											DJD
5183	10	X	X	X	X	X	X								
5185	5								LEH			TP			DJD
5187	5	X	X	X	X	X									DJD
5190	6	X	X	X		X									DJD
5191	4	X	X	X											DJD
5203	10	X			X										DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
5207	5	X								PH			TB		DJD
5208	3	X													DJD
5209	5	X	X	X	X										
5210	6								LEH	PH					DJD
5211	5	X	X	X	X	X	X	X							
5212	5	X			X										DJD
5213	5								LEH						DJD
5214	5	X													DJD
5215	8	X													DJD
5218	6														DJD
5223	10	X													DJD
5228	6	X	X	X		X		X							DJD
5229	5														DJD
5230	5	X								PH					DJD
5232	10	X		X	X	X	X	X							
5234	5	X								PH					DJD
5235	5	X				X									DJD
5236	5				X				LEH						DJD
5237	6	X													DJD
5238	3	X			X	X									DJD
5253	5	X	X	X											DJD
6229	5	X													DJD
6246	5	X													DJD
6247	5	X													DJD
6248	5	X													DJD
6249	5	X													DJD
6250	8	X													
6251	5	X													DJD
6252	5	X													DJD
6253	2	X													DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
6254	5	X										TP		TREP	DJD
6268	10	X			X										DJD
6285	10	X	X	X	X	X	X	X							
7007	8	X				X									DJD
7008	10	X			X										
7011	10				X										
7029	10	X			X							TP			DJD
7038	4														DJD
7042	6	X			X	X									DJD
7043	5														DJD
7044	8					X									DJD
7067	10									PH		TP			DJD
7071	1	X			X	X	X	X							
7095	10														DJD
7098	3	X			X	X		X							
7099	2	X			X	X	X	X							DJD
7114	10	X			X										DJD
7118	10	X													DJD
7138	5	X													DJD
7149	10	X	X	X	X		X								DJD
7167	8	X	X	X	X	X	X								DJD
7169	2	X		X	X	X									
7172	5	X													DJD
7174	10	X	X	X	X	X									
7176	8	X	X	X	X	X	X	X							
7183	10	X			X	X									DJD
7185	5	X			X	X									DJD
7186	5														
7200	8	X			X										DJD
7201	10														DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
7203	10	X			X	X									DJD
7205	5														DJD
7206	10	X			X					PH		TP			DJD
7207	10				X	X									
7208	10	X			X										
7209	8	X													DJD
7214	5														DJD
7218	10	X													DJD
7219	5														DJD
7220	5	X													DJD
7223	5														DJD
7226	5														DJD
7227	5	X													DJD
7230	10	X											TB		DJD
7231	2														DJD
7232	5				X										DJD
7234	5														DJD
7235	5														DJD
7236	5														DJD
7241	5														DJD
8016	4				X	X									DJD
8017	5				X	X						TP			
8019	4														DJD
8029	2	X													DJD
8033	5														DJD
8034	5	X													DJD
8036	5	X													DJD
8038	8	X													DJD
8040	2	X													
8043	5	X			X	X									DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
8059	5														DJD
8060	5	X													
8065	5	X			X	X									DJD
8069	5	X	X	X	X	X									DJD
8070	5	X													DJD
8074	5	X			X	X									DJD
8077	5	X										TP			DJD
8079	5	X			X										DJD
8080	4	X													DJD
8081	4	X	X												DJD
8087	6	X													DJD
8094	4	X													DJD
8099	6	X			X	X									
8106	5	X													DJD
8109	5														DJD
8110	5														DJD
8114	5														DJD
8115	5														DJD
8118	5														DJD
8119	5														DJD
8120	5			X		X									DJD
8121	5														DJD
8122	6														DJD
8123	5	X			X										DJD
8126	5														DJD
8127	5														DJD
8128	5														
8145	5														DJD
8148	6	X													DJD
8150	5	X													DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
8151	5	X													DJD
8152	4	X													
8153	6	X													DJD
8158	2														DJD
8160	5	X													DJD
8161	4	X													DJD
8162	5	X													DJD
8163	2	X													DJD
8164	5	X													DJD
8165	2	X													DJD
8166	8	X													DJD
8168	5	X													DJD
8171	2														DJD
8172	5	X													
8174	5	X	X	X	X	X	X	X							DJD
8175	5	X													DJD
8177	5	X													DJD
8178	5	X													DJD
8179	5	X	X	X								TP			DJD
8180	5	X		X											DJD
8183	6	X													DJD
8186	10	X	X	X	X	X	X	X							
8190	5	X													DJD
8192	5	X													DJD
8193	5														DJD
8195	5	X													DJD
8196	4	X			X										DJD
9101	2	X	X	X	X	X									DJD
9209	6	X													DJD
9210	5								LEH						DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
9212	5				X				LEH						DJD
9213	5	X													DJD
9215	6					X									DJD
9216	5				X										DJD
9217	10								LEH						
9219	5							X							DJD
9220	5				X			X							DJD
9221	6	X		X								TP			DJD
9222	5								LEH						DJD
9224	8				X				LEH						
9226	6	X													DJD
9227	1								LEH						DJD
9228	5	X													DJD
9232	4														DJD
9233	4														DJD
9234	3	X			X							TP			DJD
9235	6	X													DJD
9236	2														DJD
9237	5								LEH						DJD
9238	4														DJD
9239	5								LEH						DJD
9241	5								LEH						DJD
9242	6	X			X										DJD
9243	5														DJD
9244	2								LEH						DJD
9245	6	X			X	X									DJD
9249	3	X													DJD
9255	5	X													DJD
9256	6	X													DJD
9257	6														DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
9258	4								LEH						
9259	5								LEH						DJD
9261	6								LEH						DJD
9262	5								LEH						DJD
9263	6					X							TB		DJD
9266	6	X													DJD
9267	4								LEH						DJD
9268	6				X				LEH						DJD
9269	3	X													DJD
9270	5								LEH						DJD
9272	3	X													DJD
9273	6								LEH						DJD
9274	5	X													DJD
9275	5														DJD
9277	5								LEH						DJD
9278	6														DJD
9279	4								LEH	PH					
9280	5	X				X									DJD
9281	4								LEH						DJD
9282	5								LEH						DJD
9283	4								LEH						DJD
9284	5				X				LEH						
9285	5														DJD
9286	5								LEH						DJD
9287	5	X			X										DJD
9288	5	X													DJD
9289	4								LEH						DJD
9290	1								LEH						DJD
9291	4					X			LEH						DJD
9292	6														DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
9293	3		X	X								TP			DJD
9295	5														DJD
9296	6														DJD
9297	5														DJD
9299	5	X													DJD
9300	6	X													DJD
9302	6								LEH						DJD
9303	6	X	X	X											DJD
9304	5														DJD
9305	4								LEH			TP			DJD
9308	5								LEH						DJD
9309	5	X			X	X									DJD
9310	5	X													DJD
9311	4				X				LEH						
9312	4		X	X	X		X	X	LEH						
9313	8		X	X	X	X		X							
9314	1	X	X	X		X									DJD
9315	2	X				X									DJD
9317	5	X	X	X	X	X									DJD
9318	1		X	X			X	X	LEH						DJD
9333	1	X				X	X	X							DJD
9342	6	X													DJD
9343	3	X	X	X											DJD
9344	5		X	X	X	X									DJD
9345	6	X													DJD
9346	5			.		X									DJD
9347	3	X									CO	TP			DJD
9348	5	X													DJD
9349	6				X				LEH			TP			DJD
9350	10								LEH						DJD

Table 71: cont'd

Burial #	Age/Sex	AT	PAR	ORB	RIB	VER	FEM	TIB	LEH	PH	CO	TP	TB	TREP	DJD
9351	2	X													DJD
9352	6	X													DJD
9353	5								LEH						DJD
9354	2														DJD
9355	2	X													DJD
9356	5								LEH			TP			DJD
9357	5								LEH						DJD
9358	5								LEH						DJD
9359	5														DJD
9362	6				X				LEH						DJD
9363	5											TP			DJD
9364	8	X			X	X									DJD
9365	5								LEH						DJD
9366	4	X													DJD
9367	5														DJD
9368	6														DJD
9369	4														DJD
9370	1	X	X	X											DJD
9371	5	X	X	X											DJD
9398	10	X	X	X	X	X	X								
9473	10	X	X	X	X	X	X	X							

MCIG Subadult Table Key

Burial #:	Excavated burial lot number
Age/Sex:	1 – Infant (<1 year) 2 – Child (1-4.9 years) 3 – Juvenile (5-19.9 years) 4 – Unknown age
AT:	Anterior teeth X = Incomplete, absent, or unable to be used for analysis
PAR:	Parietal X = Incomplete, absent, or unable to be used for analysis
ORB:	Eye orbit X = Incomplete, absent, or unable to be used for analysis
FEM:	Femur X = Incomplete, absent, or unable to be used for analysis
TIB:	Tibia X = Incomplete, absent, or unable to be used for analysis
LEH:	Linear enamel hypoplasia LEH = present
PH:	Porotic hyperostosis PH = present
CO:	Cribra orbitalia CO = present
TP:	Tibial periostitis TP = present

Table 72, MCIG Subadult Summary, follows this page.

Table 72: MCIG Subadult Summary

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
2109	1	X	X	X						
5117	2	X	X							
6000	1			X						
6001	1	X	X	X						
6002	1		X							
6003	1	X	X							
6004	1	X								
6005	1									
6006	1	X								
6008	1	X								
6010	1		X	X						
6011	1	X	X	X						
6013	1									
6014	1									
6015	1	X	X	X						
6016	1	X								
6017	1						LEH			
6018	1	X	X	X						
6019	1	X	X	X						
6020	1	X	X	X						
6021	1									
6022	1									
6023	1	X								
6024.1	1	X								
6025	1	X								
6026	1									
6028	1	X								
6030	1									
6031	1						LEH	PH	CO	
6032	1	X								

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
6034	1									
6035	1									
6036	1	X								
6038	1	X	X	X						
6039	1	X								
6040	1									
6042	1	X	X	X						
6043	1	X	X	X						
6044	1	X	X	X						
6045	1	X	X							
6046	1									
6047	1	X								
6048	1									
6049	1	X								
6050	1									
6051	1									
6052	2						LEH			
6053	1									
6054	1									
6055	1									
6056	1									
6057	1									
6058	1									
6059	1									
6060	1	X	X							
6062	1		X	X						
6063	1		X							
6064	1									
6065	1		X							
6066	1	X	X							

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
6067	1									
6068	1									
6069	1	X			X	X				
6070	1		X				LEH			
6071.1	1	X	X							
6071.2	1	X	X		X					
6073	1		X	X	X	X				
6074	1		X	X						
6075	1			X						
6076	1			X						
6077	1			X						
6078.1	1		X							
6078.2	1		X							
6079	1	X	X	X						
6080	1									
6081	1									
6082	1									
6085	1	X	X							
6086	1		X							
6090	1	X	X							
6094	1	X	X	X						
6096	4	X	X							
6097	1		X				LEH			
6098	1		X							
6099	1	X	X							
6101	2		X							
6103	1	X	X							
6104	1	X	X							
6105	1	X	X							
6106	1									

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
6107	1		X							
6110	1	X	X							
6116	1		X							
6117	1		X							
6119	1	X	X	X		X				
6126	1		X							
6127	1						LEH	PH	CO	
6128	1		X							
6129	1		X							
6130	1									
6131	1									
6132	1		X							
6133	1	X	X							
6134	1	X								
6135	1	X								
6136	1	X	X							
6137	1	X	X							
6138	1		X	X	X		LEH			
6139	1		X							
6141	4	X	X		X	X				
6142	1		X							
6143	1	X	X							
6146	1		X							
6147	1		X							
6151	2						LEH			
6154	1		X							
6157	1		X	X		X		PH		
6159	1		X	X		X				
6160	1	X	X							
6161	1	X								

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
6162	1	X								
6163	1		X							
6164	2						LEH			
6165	1		X							
6167	1	X	X							
6168	1	X								
6169	2						LEH			
6170	1		X							
6171	1									
6172	2		X				LEH			
6173	1	X	X	X						
6174	1		X	X						
6175	1									
6176	1									
6177	1	X								
6178	1	X								
6179	1									
6180	1		X							
6181	1	X	X							
6183	1		X							
6184	1	X	X							
6186	1		X							
6189	1		X							
6192	1		X							
6193	4	X	X	X						
6194	1		X							
6195	1	X	X	X						
6197	1	X	X							
6198	1	X	X							
6199	1		X	X						

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
6200	2									
6201	1									
6202	1	X								
6203	1									
6204	1	X	X							
6205	1	X	X	X						
6207	4	X								
6208	1	X								
6209	1	X				X				
6210	1			X						
6211	1	X								
6212	1									
6213	1									
6215	1		X	X						
6216	1									
6217	1	X								
6218.1	1									
6220	1									
6221	1	X		X						
6223	1		X							
6224	2	X	X	X		X				
6225	4	X	X							
6228	4	X	X							
6234	1	X	X	X		X				
6235	4	X	X							
6236	1	X								
6237	1									
6238	1									
6239	1									
6240	1									

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
6241	1	X								
6242	1	X		X						
6243	1	X		X						
6255	1		X	X	X	X				
6256	1									
6257	1	X	X	X						
6260	1		X	X						
6262	1		X							
6263.1	1		X	X		X				
6263.2	1		X	X		X				
6264.1	1		X	X						
6264.2	1		X	X		X				
6272.1	1		X	X						
6272.2	1		X	X						
6273	1		X	X	X	X				
6277	1		X	X		X				
6278	1			X	X	X				
6279	1	X	X	X	X	X				
6286	1	X	X	X						
6290	1									
7121	1		X							
7122	1		X							
7123	1		X							
7124	2		X				LEH	PH		TP
7125	1		X							
7126	1	X	X	X						
7127	1		X				LEH			TP
7128	1	X	X	X		X				
7129	4	X	X							
7131	1	X	X							

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
7132	1		X							
7133	1	X	X			X				
7139	1		X							
7140	2						LEH		CO	TP
7141	1		X	X						
7142	1		X							
7143	1	X	X			X				
7246	1									
7248	1	X	X			X				
7249	4	X	X	X						
7251	1	X	X			X				
7253	1	X	X			X				
7256	1		X							
7257	1		X	X	X	X				
8129	3									
8146	3									
8167	3	X	X							
9004	1		X	X						
9006	1		X	X						
9007	1		X	X						
9008	1		X	X						
9009	1		X	X						
9010	4	X	X							
9014	1		X	X		X	LEH			
9015	1	X	X	X						
9016	1		X	X	X	X				
9018	1		X	X		X				
9019	1		X	X						
9023	1		X	X		X				
9025	1			X	X	X		PH		

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
9026	1	X	X	X						
9027	1	X	X	X						
9030	1		X	X		X				
9035	1		X	X		X				
9036	4	X	X							
9040	4	X	X	X	X					
9043	1		X	X		X				
9044	1		X	X		X				
9045	1		X	X		X				
9046	1		X	X		X				
9047	1		X	X		X				
9051	4	X	X	X						
9058	4	X	X	X						
9061	1		X	X		X				
9062	1		X	X		X	LEH			
9066	1		X	X						
9068	1	X	X							
9069	1		X	X	X	X	LEH			
9073	1	X	X	X						
9074.1	1	X	X	X						
9074.2	1	X	X	X						
9075	1	X	X	X						
9078	1	X	X	X						
9079	1		X	X						
9080	1		X	X						
9081	1		X	X		X	LEH			
9082	1		X	X		X				
9083	1		X	X		X	LEH			
9084	1		X			X				
9085	1		X	X						

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
9087	1		X	X						
9091	1		X	X		X				
9093	1		X	X		X				
9094	1		X	X						
9095	1		X							
9096	1		X							
9097	1	X	X	X						
9099	1		X	X		X				
9102	1	X	X	X	X	X				
9104	1	X	X							
9105	1		X	X						
9106	1		X	X						
9108	1	X	X			X				
9109	1	X	X	X	X	X				
9111	1	X	X	X						
9113	1		X	X						
9115	1		X	X						
9116	1		X							
9119	1		X	X						
9120	1		X	X						
9121	1		X	X	X	X				
9125	1		X		X	X				
9128	1		X	X	X	X				
9129	1	X	X	X						
9138	4	X	X	X	X	X				
9140	1	X	X			X				
9141	1		X	X						
9142	1	X	X	X						
9143	4	X	X							
9144	1		X	X		X				

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
9146	1	X	X	X						
9147	1	X	X			X				
9148	1	X	X	X						
9149	1		X	X						
9150	1	X	X	X						
9153	1		X	X						
9156	1	X	X	X						
9161	1	X	X	X						
9164	1		X	X						
9168	1	X	X							
9170	1		X	X	X	X				
9171	2		X	X	X	X	LEH			
9172	2		X	X		X				
9175	1		X	X		X				
9176	2		X				LEH			
9177	2		X	X						
9178	1		X	X		X				
9179	1			X	X	X		PH		
9180	4	X	X	X						
9183	1		X	X		X				
9186	1		X	X		X				
9187	2		X	X		X				
9189	1		X	X	X	X				
9190	1	X	X	X						
9191	1		X	X		X	LEH			
9192	1	X	X	X						
9194	1	X	X	X						
9202	1					X	LEH	PH		
9203	1		X	X						
9204	1					X	LEH	PH		

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
9205	2					X	LEH	PH		
9207	4	X	X	X						
9209	1		X		X					
9264	3						LEH			
9266	3									
9319	2	X	X	X	X	X				
9321	3								CO	TP
9323	1	X	X	X	X	X				
9324	2		X		X		LEH			
9325	1		X	X	X	X				
9327	1		X	X						
9336	1	X	X	X						
9338	1		X	X						
9339	1		X	X						
9341	1	X	X	X						
9377	1		X	X		X				
9379	1		X	X						
9386	1	X	X	X		X				
9387	1		X	X						
9388	1	X	X	X						
9390	1		X	X	X	X	LEH			
9393	1		X	X			LEH			
9394	1	X	X	X						
9400	1	X	X	X	X	X				
9401	2	X	X	X	X					
9404	1	X	X							
9405	1	X	X	X						
9409	1			X	X	X	LEH	PH		
9410	1	X	X	X						
9412	1		X	X						

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
9413	1	X	X	X						
9415	1		X	X	X	X	LEH			
9416	1		X	X						
9419	1		X	X		X				
9420	1		X	X			LEH			
9422	1	X	X	X						
9423	1	X	X	X						
9427	1	X	X	X		X				
9429	1		X	X						
9430	1		X	X						
9431	1		X	X	X	X				
9432	1		X	X		X				
9433	1	X	X	X		X				
9434	1		X	X						
9440	1		X	X		X				
9441	1	X	X	X						
9442	1	X	X	X		X				
9444	4	X	X							
9445	1	X	X			X				
9446	1		X							
9448	1		X	X		X				
9449	1		X			X				
9450	1		X	X						
9451	1	X	X	X						
9452	1		X				LEH			
9453	1		X	X						
9454	1	X	X	X						
9458	1		X	X						
9461	1		X	X						
9462	1		X	X						

Table 72: cont'd

Burial #	Age	AT	PAR	ORB	FEM	TIB	LEH	PH	CO	TP
9464	1		X	X		X				
9465	2		X	X	X	X	LEH			

Appendix B

Paleopathology Photographs from the MCIG cemetery

The photographs included in this appendix illustrate the indicators of health used in this study and are intended to provide examples of the types of pathological conditions included in the skeletal analysis. Specific areas of interest are indicated with an arrow. All photographs are labeled with the burial number and a description of the paleopathology observed in the photo. Photos taken by someone other than the author of this dissertation are marked with a photo credit included beneath the picture. The photographs proceed in the following order:

Linear Enamel Hypoplasias (LEH)
Porotic Hyperostosis
Cribra orbitalia
Periostitis and Osteomyelitis
Specific infection – Tuberculosis
Specific infection – Treponemal Infection
Degenerative Joint Disease
Degenerative Disease – Possible Aortic Aneurysm
Degenerative Disease – Osteoblastic Lesion/Carcinoma

Figure 57: Burial 5120 – LEH, right maxillary 1st incisor, labial view

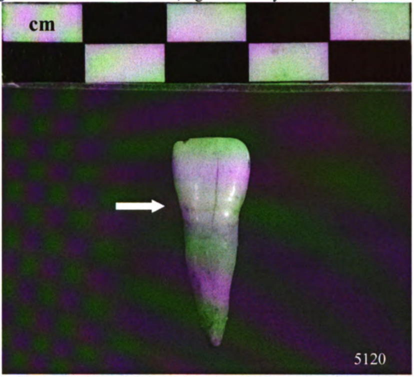

Photo: Katie Rudolph, University of Wisconsin-Milwaukee

Figure 58: Burial 5120 – LEH, right maxillary 1st incisor, mesial view

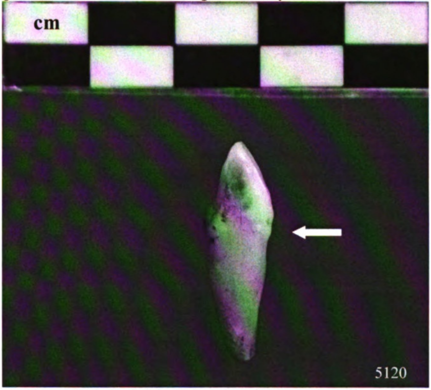

Photo: Katie Rudolph, University of Wisconsin-Milwaukee

Figure 59: Burial 5120 – LEH, right maxillary 1st incisor, distal view

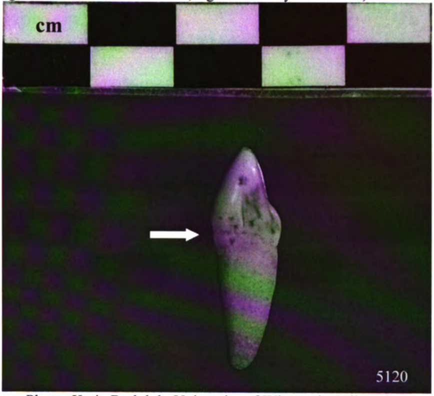

Photo: Katie Rudolph, University of Wisconsin-Milwaukee

Figure 60: Burial 9349 – LEH, right mandibular canine, labial view

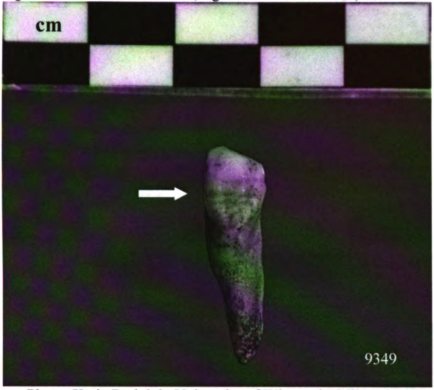

Photo: Katie Rudolph, University of Wisconsin-Milwaukee

Figure 61: Burial 9349 – LEH, right mandibular canine, mesial view

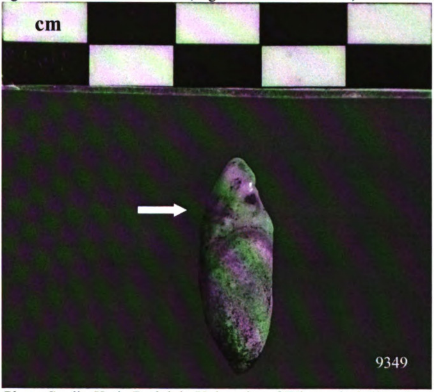

Photo Credit: Katie Rudolph, University of Wisconsin-Milwaukee

Figure 62: Burial 9349 – LEH, right mandibular canine, distal view

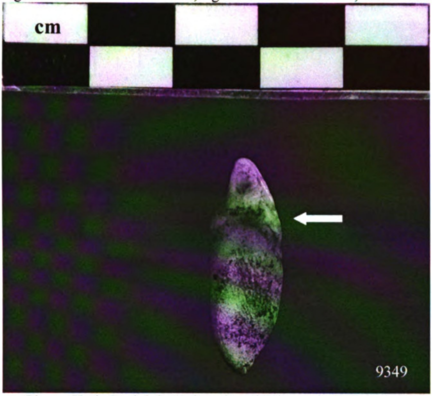

Photo: Katie Rudolph, University of Wisconsin-Milwaukee

Figure 63: Burial 1009 – Porotic hyperostosis, left frontal, near frontal boss and adjacent to suture

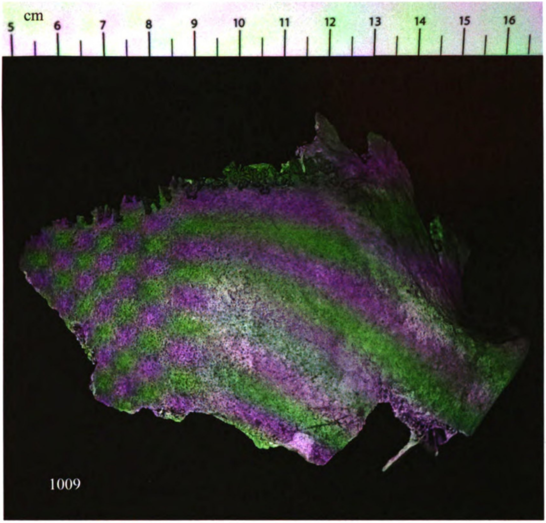

Figure 64: Burial 8007 – Porotic hyperostosis, frontal, parietals, adjacent to sutures

Figure 65: Burial 9234 – Cribra orbitalia, left eye orbit

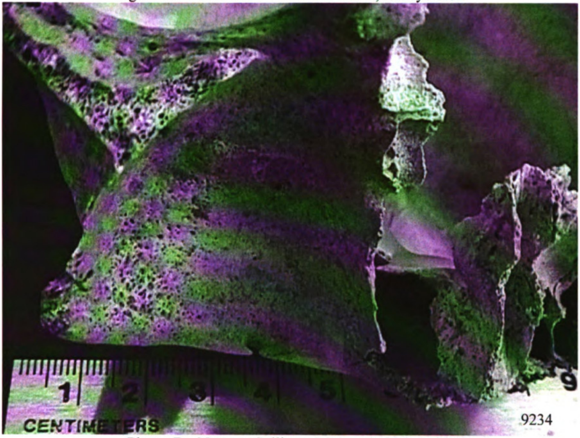

Photo: Dr. Norman Sullivan, Marquette University

Figure 66: Burial 8017 – Periostitis, distal right femur

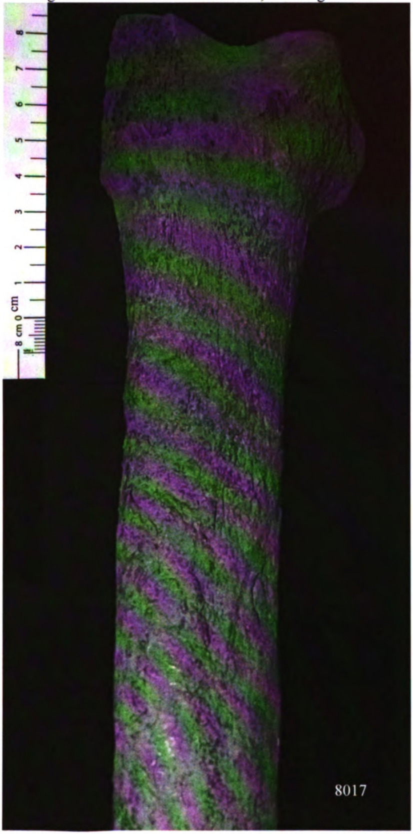

Figure 67: Burial 8198 – Osteomyelitis, right femur and tibia

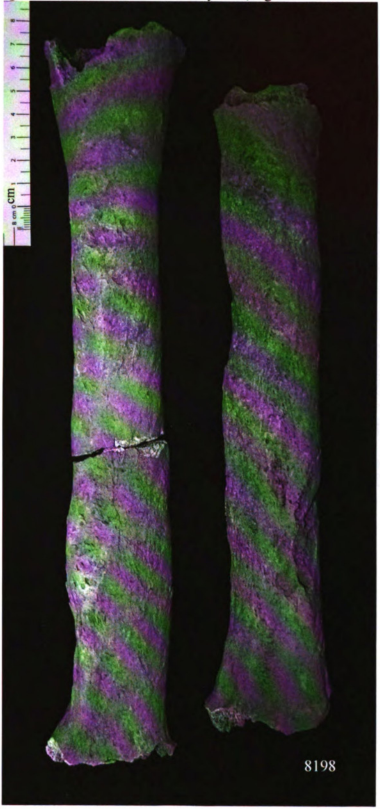

Figure 68: Burial 8198 - Narrowing of the marrow cavity due to osteomyelitis, cross-section of the midshaft of right femur

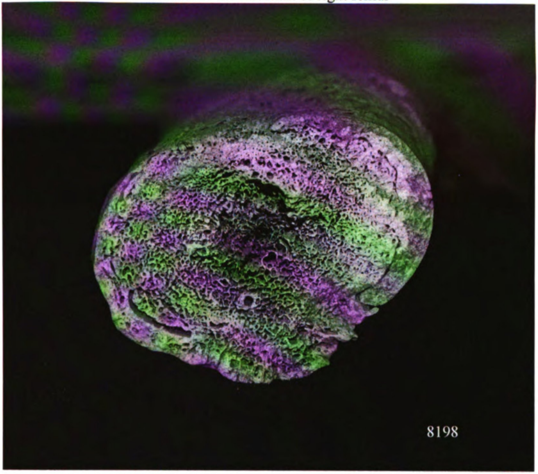

Figure 69: Burial 3039 - Lytic lesion, tuberculosis, T12 thoracic vertebrae

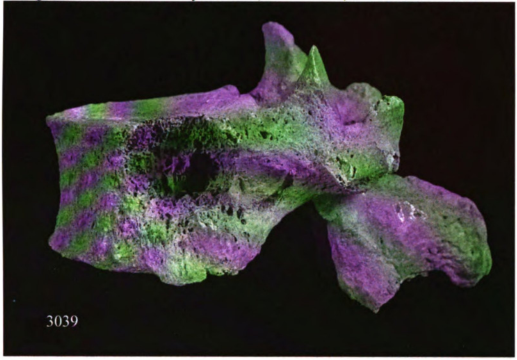

Figure 70: Burial 3039 - Lytic lesion, tuberculosis, L2 lumbar vertebrae

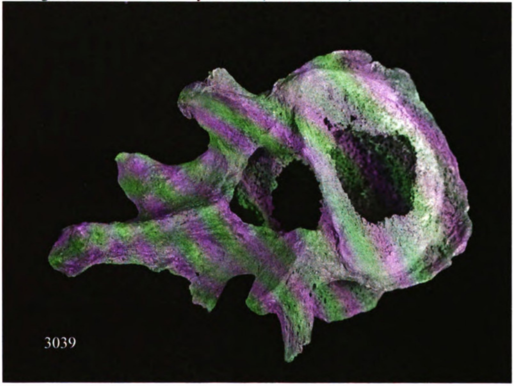

Figure 71: Burial 3039 – Lytic lesion, tuberculosis, L3 lumbar vertebrae

Figure 72: Burial 3039 - Lytic lesion, tuberculosis, right ilium

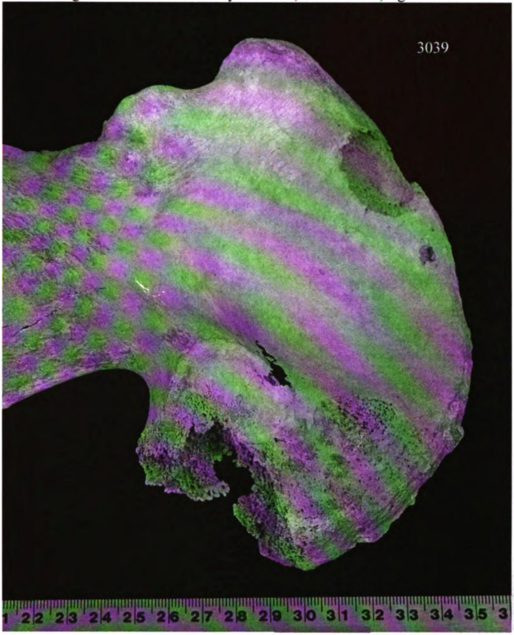

Figure 73: Burial 2003 - Lytic lesion on rib fragment, tuberculosis

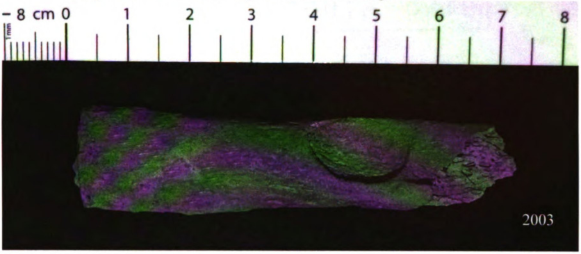

Figure 74: Burial 2003 - Reactive bone formation on rib fragment, tuberculosis

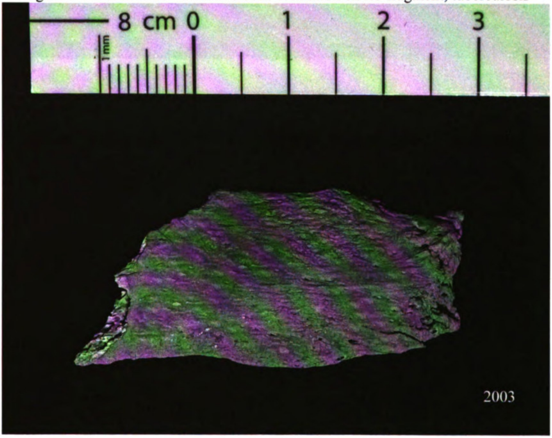

Figure 75: Burial 6254 - Healed cranial lesions, possible treponemal infection, parietals

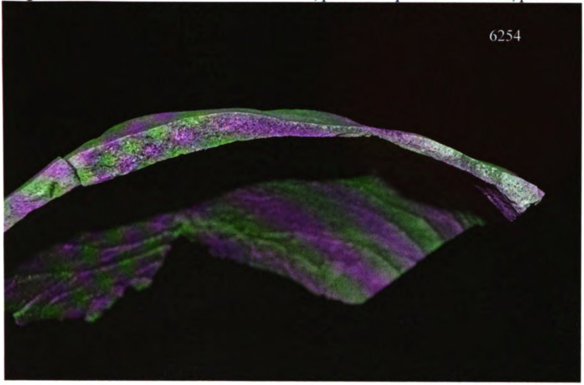

Figure 76: Burial 6254 - Periostitis, possible treponemal infection, left femur, tibia, and fibula (black staining on tibia and fibula not pathological)

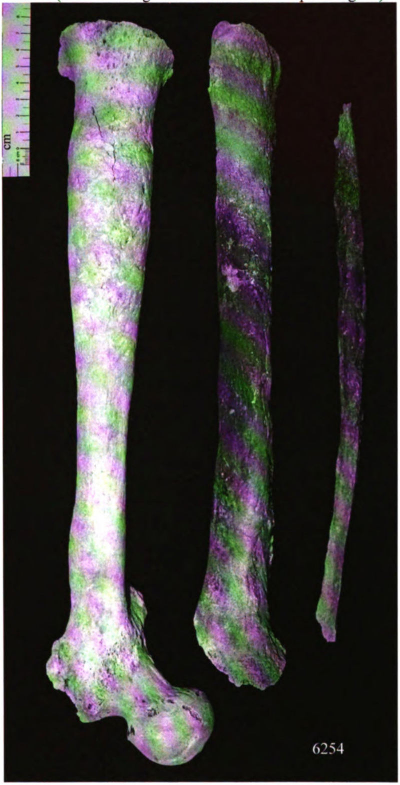

Figure 77: Burial 3048 – Osteoarthritic lipping, proximal left and right ulna

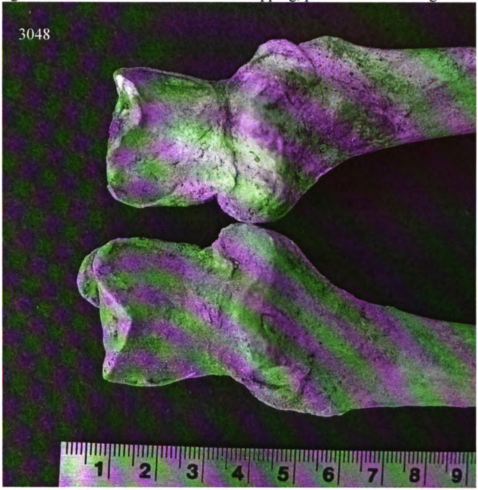

Photo: Dr. Norman Sullivan, Marquette University

Figure 78: Burial 9279 – Possible aortic aneurysm, T9-12 thoracic vertebrae

Figure 79: Burial 9242 - Osteoblastic lesion, lateral view of the mandible

Photo: Dr. Norman Sullivan, Marquette University

Figure 80: Burial 9242 - Osteoblastic lesion, medial view of the mandible

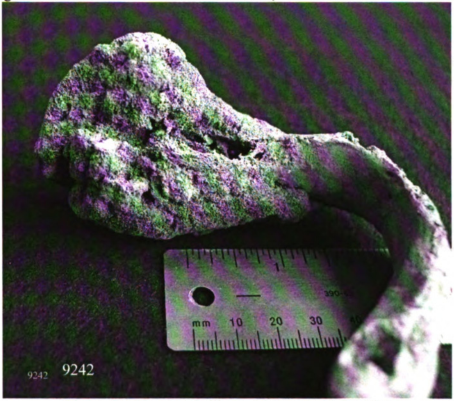

Photo: Dr. Norman Sullivan, Marquette University

REFERENCES

Aufderheide and Rodríguez-Martín. 1998. *The Cambridge Encyclopedia of Human Paleopathology*. Cambridge: Cambridge University Press.

Bachman R and R Paternoster. 1997. *Statistical Methods for Criminology and Criminal Justice*. New York: McGraw-Hill.

The Backbone of History: Health and Nutrition in the Western Hemisphere. 2002. RH Steckel and JC Rose (eds). Cambridge: Cambridge University Press.

Baker B. 2005 Patterns of Pre- and Post-Columbian Treponematosis in the Northeastern United States. In: *The Myth of Syphilis: The Natural History of Treponematosis*. ML Powell and DC Cook (eds). Gainesville: University of Florida Press.

Barrett R, CW Kuzawa, T McDade, and GJ Armelagos. 1998. Emerging and Re emerging Infectious Diseases: The Third Epidemiological Transition. *Annual Review of Anthropology* 27: 247-71.

Boldsen JL. 2007. Early childhood stress and adult age mortality – A study of dental enamel hypoplasia in the medieval Danish village of Tirup. *American Journal of Physical Anthropology* 132(1): 59-66.

Booth DE. 1985. Municipal Socialism and City Government Reform: The Milwaukee Experience, 1910-1940. *Journal of Urban History* 12: 51-71.

Brooks ST and JM Suchey. 1990. Skeletal Age Determination Based on the Os Pubis: A Comparison of the Acsádi-Nemeskéri and Suchey-Brooks Methods. *Human Evolution* 5: 227-238.

Buikstra JE and DC Cook. 1980. Palaeopathology: An American account. *Annual Review of Anthropology* 9: 433-470.

Buzon MR and MA Judd. 2008. Investigating health at Kerma: Sacrificial versus nonsacrificial individuals. *American Journal of Physical Anthropology* 136(1): 93-99.

Charaus B. 2005. Service Institutions in Milwaukee: Introduction. In: *Milwaukee Stories.* TJ Jablonsky (ed). Milwaukee, WI: Marquette University Press.

Clark GA, MA Kelley, JM Grange, MC Hill, MA Katzenberg, LL Klepinger, NC Lovell, J McGrath, MS Micozzi, and RT Steinbock. 1987. The Evolution of Mycobacterial Disease in Human Populations: A Reevaluation. *Current Anthropology* 28(1): 45-62.

County Health Rankings. Robert Wood Johnson Foundation and the University of Wisconsin Population Health Institute. Retrieved online 1 March 2010. www.countyhealthrankings.org.

Devitt L, C Milligan, and N Sullivan. 2006. *Using Archival and Biological Data to Link Names to Burials in an Early 20th Century Pauper Cemetery.* Paper Presentation. Midwest Bioarchaeology and Forensic Anthropology Association Annual Meeting.

Dougherty S, J Zotcavage, C Milligan, J Ivany, A Mann, and N Sullivan. 2005. *Little Deaths: Infant and child mortality from a late 19th century poorhouse cemetery.* Poster Presentation. American Association of Physical Anthropology Annual Meeting. *American Journal of Physical Anthropology* 126(S40): 96.

Duffy J. 1978. Social Impact of Disease in the Late 19th Century. In: *Sickness and Health in America: Readings in the History of Medicine and Public Health.* JW Leavitt and RL Numbers (eds). Madison, WI: The University of Wisconsin Press.

Fazekas G and F Kosa. 1978. *Forensic Fetal Osteology.* Budapest: Akademiai Kiado.

Fenner F. 1970. The Effects of Changing Social Organization on the Infectious Diseases of Man. In: *The Impact of Civilisation on the Biology of Man.* SV Boyden (ed). Toronto: University of Toronto Press.

Fox DM. 1978. Social Policy and City Politics: Tuberculosis Reporting in New York, 1889-1900. In: *Sickness and Health in America: Readings in the History of Medicine and Public Health.* JW Leavitt and RL Numbers, eds. Madison, WI: The University of Wisconsin Press.

Gage TB. 2005. Are Modern Environments Really Bad for Us?: Revisiting the Demographic and Epidemiologic Transitions. *Yearbook of Physical Anthropology* 48: 96-117.

Goodman AH and DL Martin. 2002. Reconstructing Health Profiles from Skeletal Remains. In: *The Backbone of History: Health and Nutrition in the Western Hemisphere.* RH Steckel and JC Rose (eds). Cambridge: Cambridge University Press.

Goodman AH and JC Rose. 1990. Assessment of Physiological Perturbations from Dental Enamel Hypoplasias and Associated Histological Structures. *Yearbook of Physical Anthropology* 33: 59-110.

Goodman AH and JC Rose. 1991. Dental enamel hypoplasias as indicators of nutritional status. In: *Advances in Dental Anthropology.* MA Kelley and CS Larsen (eds). New York: Wiley-Liss.

Goodman AH, RB Thomas, AC Swedlund, and GJ Armelagos. 1988. Biocultural Perspectives on Stress in Prehistoric, Historic, and Contemporary Population Research. *Yearbook of Physical Anthropology* 31: 169-202

Grauer AL and EM McNamara. 1995. A Piece of Chicago's Past: Exploring Childhood Mortality in the Dunning Poorhouse Cemetery. In: *Bodies of Evidence.* AL Grauer, ed. New York: John Wiley & Sons.

Grauer AL, EM McNamara, and DV Houdek. 1998. A History of Their Own: Patterns of death in a nineteenth-century poorhouse. In: *Sex and Gender in Paleopathological Perspective.* AL Grauer and P Stuart-Macadam (eds). Cambridge: Cambridge University Press.

Gurda J. 2006. *The Making of Milwaukee*, 3rd Ed. Brookfield, WI: Milwaukee County Historical Society.

A Half Century of Public Health. 1921. MP Ravenel (ed). New York: American Public Health Association.

Hetzner A, M Johnson, and S Durhams. 2009. "More area schools close; swine flu suspected". *Milwaukee Journal Sentinel Online*. Retrieved: 20 October 2009.

Higgins RL and JE Sirianni. 1995. An Assessment of Health and Mortality of Nineteenth Century Rochester, New York Using Historic Records and The Highland Park Skeletal Collection. In: *Bodies of Evidence*. AL Gauer, ed. New York: John Wiley & Sons.

Higgins RL, MR Haines, L Walsh, and JE Sirianni. 2002. The Poor in Mid-Nineteenth Century Northeastern Unites States: Evidence from the Monroe County Almshouse, Rochester, New York. In: *The Backbone of History: Health and Nutrition in the Western Hemisphere*. RH Steckel and JC Rose (eds). Cambridge: Cambridge University Press.

Hinton PR, C Brownlow, I McMurray, and B Cozens. 2004. *SPSS Explained*. London: Routledge.

Holland TD and MJ O'Brien. 1997. Parasites, Porotic Hyperostosis, and the Implications of Changing Perspectives. *American Antiquity* 62(2): 183-193.

Human Remains from Voegtly Cemetery, Pittsburgh, Pennsylvania. 2003. DH Ubelaker and EB Jones (eds). Washington D.C.: Smithsonian Institution Press.

Kahn HA and CT Sempos. 1989. Statistical Methods in Epidemiology. New York: Oxford University Press.

Klaus HD and ME Tam. 2009. Contact in the Andes: Bioarchaeology of Systemic Stress in Colonial Mórrope, Peru. *American Journal of Physical Anthropology* 138: 356-368.

Krogman WM and MY Iscan. 1986. *The Human Skeleton in Forensic Medicine*. WM Iscan and MY Iscan (eds). Springfield: Charles C. Thomas.

Lanphear KM. 1988. Health and Mortality in a Nineteenth-Century Poorhouse Skeletal Sample. Dissertation. State University of New York - Albany.

Larsen CS. 1997. *Bioarchaeology: Interpreting behavior from the human skeleton.* Cambridge: Cambridge University Press.

Leavitt JW. 1978. Politics and Public Health: Smallpox in Milwaukee, 1894-1895. In: *Sickness and Health in America: Readings in the History of Medicine and Public Health.* JW Leavitt and RL Numbers, eds. Madison, WI: The University of Wisconsin Press.

Leavitt JW. 1982. *The Healthiest City: Milwaukee and the Politics of Health Reform.* Princeton, NJ: Princeton University Press.

Lovejoy Co, RS Meindl, TR Pryzbeck, and RP Mensforth. 1985. Chronological Metamorphosis of the Auricular Surface of the Ilium: A New Method for the Determination of Age at Death. *American Journal of Physical Anthropology* 68: 15-28.

Lukacs J. 1992. Dental Paleopathology and Agricultural Intensification in South Asia: New Evidence From Bronze Age Harappa. *American Journal of Physical Anthropology* 87: 133-150.

Maresh MM. 1955. Linear growth of long bones of extremities from infancy through adolescence. *A.M.A. American Journal of Diseases of Children* 89: 725-742.

Maresh MM. 1970. Measurements from roentgenograms. In: *Human Growth and Development.* RW McCammon (ed). Springfield, IL: C.C. Thomas.

Mays S, M Brickley, and R Ives. 2008. Growth in an English Population From the Industrial Revolution. *American Journal of Physical Anthropology* 136: 85-92.

Meindl RS and CO Lovejoy. 1989. Age Changes in the Pelvis: Implications for Paleodemography. In: *Age Markers in the Human Skeleton.* MY Iscan (ed). Springfield, IL: C.C. Thomas.

Melosi M. 2000. *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present*. Baltimore: The John Hopkins University Press.

Milligan C, L Devitt, and N Sullivan. 2008. *A comparison of age estimations and burial records from a late nineteenth and early twentieth century almshouse cemetery.* Paper Presentation. American Association of Physical Anthropology Annual Meeting. *American Journal of Physical Anthropology* 135(S46):155-156.

Milwaukee Health Department (MHD) Annual Reports:
11th Annual Report of the Board of Health of the City of Milwaukee 1877
18th Annual Report of the Commissioner of Health of Milwaukee 1895
20th Annual Report of the Commissioner of Health of Milwaukee 1897
22nd Annual Report of the Commissioner of Health of Milwaukee 1899
Milwaukee's Health: Annual Report of the Department of Health 1931

Moorrees C, E Fanning, and E Hunt. 1963a. Age variation of formation stages for ten permanent teeth. *Journal of Dental Research* 42: 1490-1502.

Moorrees C, E Fanning and E Hunt. 1963b. Formation and resorption of three deciduous teeth in children. *American Journal of Physical Anthropology* 21: 205-213.

Omran AR. 1977. Epidemiological transition in the U.S. *Population Bulletin* 32: 1-42.

Ortner DJ. 2003. *Identification of Pathological Conditions in Human Skeletal Remains*. Boston: Academic Press.

Phenice T. 1969. A Newly Developed Visual Method of Sexing in the Os Pubis. *American Journal of Physical Anthropology* 30: 297-301.

Powell ML and DC Cook. 2005a. Introduction. In: *The Myth of Syphilis: The Natural History of Treponematosis*. ML Powell and DC Cook (eds). Gainesville: University of Florida Press.

Powell ML and DC Cook. 2005b. Treponematosis: Inquiries into the Nature of a Protean Disease. In: *The Myth of Syphilis: The Natural History of Treponematosis*. ML Powell and DC Cook (eds). Gainesville: University of Florida Press.

Register of Burial at Milwaukee County Poor Farm 1882-1925. Milwaukee County Records. Located at the Milwaukee County Historical Society.

Richards PB. 1997. *Unknown Man No. 198: The Archaeology of the Milwaukee County Poor Farm Cemetery.* Dissertation, University of Wisconsin-Milwaukee.

Richards PB. and MW Kastell. 1993. Archaeological Excavations at the Almshouse Burial Ground, Milwaukee County Poorhouse, Wauwatosa, Wisconsin. *Reports of Investigation No. 333, Great Lakes Archaeological Research Center, Inc.*

Roberts CA and JE Buikstra. 2003 *The Bioarchaeology of Tuberculosis: A Global View on a Reemerging Disease.* Gainesville: University of Florida Press.

Selvin S. 1996. Statistical Analysis of Epidemiological Data 2nd Ed. New York: Oxford University Press.

Standards for Data Collection from Human Skeletal Remains. 1994. JE Buikstra and DH Ubelaker (eds). Research Series, no. 44. Arkansas Archaeological Survey, Fayetteville.

Steckel RH, CS Larsen, PW Sciulli, and PL Walker. 2002a. A History of Health in Europe over the Past 10,000 Years: Summary of a Research Proposal. Online: http://global.sbs.ohio-state.edu. Retrieved 20 August 2009.

Steckel RH, PW Sciulli, and JC Rose. 2002b. A Health Index from Skeletal Remains. In: *The Backbone of History: Health and Nutrition in the Western Hemisphere.* RH Steckel and JC Rose (eds). Cambridge: Cambridge University Press.

Still B. 1948. *Milwaukee: The History of a City.* Madison, WI: The State Historical Society of Wisconsin.

Stuart-Macadam P. 1992. Anemia in Past Human Populations. In: *Diet, Demography and Disease: Changing Perspectives on Anemia.* P Stuart-Macadam and Kent (eds). New York: Aldine.

Suchey J and D Katz. 1986. Skeletal Age Standards Derived from an Extensive Multiracial Sample of Modern Americans. Abstract. *American Journal of Physical Anthropology* 69: 269.

Sullivan NC, C Milligan and S Dougherty. 2007. A Report on the Nonadult Burials from the Milwaukee County Institutional Grounds Cemetery. On file with the State Historical Society of Wisconsin, Madison.

Sullivan NC, S Dougherty, C Milligan, and L Devitt. 2008. A Summary of Analyses of the Adult Skeletal Remains from the Milwaukee County Institutional Grounds Cemetery. On file with the State Historical Society of Wisconsin, Madison.

Todd TW. 1921a. Age Changes in the Pubic Bone I: The Male White Pubis. *American Journal of Physical Anthropology* 3: 285-334.

Todd TW. 1921b. Age Changes in the Pubic Bone III: The Pubis of the White Female. IV: The Pubis of the female white-negro hybrid. *American Journal of Physical Anthropology* 4: 1-70.

Trotter M. 1970. Estimation of stature from intact long limb bones. In: *Personal Identification in Mass Disasters*. TD Stewart (ed). Washington D.C.: Smithsonian Institution Press.

Ubelaker DH. 1989a. *Human Skeletal Remains*. Washington, D.C.: Taraxacum

Ubelaker DH. 1992. Porotic Hyperostosis in Prehistoric Ecuador. In: *Diet, Demography and Disease: Changing Perspectives on Anemia*. P Stuart-Macadam and Kent (eds). New York: Aldine.

Waldron T. 2007. *Palaeoepidemiology: The Measure of Disease in the Human Past*. Walnut Creek, CA: Left Coast Press.

Walker PL, RR Bathurst, R Richman, T Gjerdrum, and VA Andrushko. 2009. The Causes of Porotic Hyperostosis and Cribra Orbitalia: A Reappraisal of the Iron-Deficiency-Anemia Hypothesis. *American Journal of Physical Anthropology* 139: 109-125.

Weaver DS, MK Sandford, G Bogdan, GE Kissling, and ML Powell. 2005. Prehistoric Treponematosis on the North Carolina Coast. In: *The Myth of Syphilis: The Natural History of Treponematosis*. ML Powell and DC Cook (eds). Gainesville: University of Florida Press.

White T. 2000. *Human Osteology*, 2nd ed. San Diego: Academic Press.

Wilbur AK, AW Farnbach, KJ Knudson, and JE Buikstra. 2008. Diet, Tuberculosis, and the Paleopathological Record. *Current Anthropology* 49(6): 963-991.

Wood J, G Milner, H Harpending, and K Weiss. 1992. The Osteological Paradox. *Current Anthropology* 33(4): 343-370.

World Health Statistics. 2009. Geneva, Switzerland: World Health Organization Press.