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Health, Nutrition, and Disease in Rural Northern Jordan: A Study of Enamel Defects Related to Childhood Stress in Skeletal Samples from the Bronze Age to the Byzantine Period

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Health, Nutrition, and Disease in Rural Northern Jordan: A Study of Enamel Defects Related to Childhood Stress in Skeletal Samples from the Bronze Age to the Byzantine Period

Health, Nutrition, and Disease in Rural Northern Jordan: A Study of Enamel Defects Related to Childhood Stress in Skeletal Samples from the Bronze Age to the Byzantine Period

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy in Anthropology

by

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Abstract

Northern Jordan has seen periods of climate change, political transformation, and economic prosperity between the Late Bronze Age to the end of the Byzantine Period. This research tests the assumption that the rural agricultural communities of this region were undernourished by examining the dentition for periodic childhood stress. Canine teeth from five sites (Ya’amun, Sa’ad, Yasileh, Natfieh, and Waqqas) that covered the time periods in question were collected to study overall quality of life..

The teeth were thin-sectioned and examined under a light microscope. Digital micrographs were made of the thin-sectioned teeth in order to record the number and location of enamel defects. Canines have been shown to be the most susceptible to the stressors that cause surface enamel defects. Linear enamel hypoplasias (LEHs) and Wilson bands are enamel defects resulting from systemic stress during the formation of enamel. LEHs form in response to severe and long-term nutritional deficiencies, while Wilson bands can develop under short periods of minor stress.

The statistical analyses revealed trends in the frequency and timing of enamel defects within the sample. An increase in both LEHs and Wilson bands was seen in the years when weaning is expected to occur. A climate shift from lower annual rainfall to higher annual rainfall has been documented within the study time period, however there is no evidence for reduced nutritional stress in the form of fewer enamel defects in the later periods. An increase in Wilson bands is seen in Roman and Byzantine periods as compared to the Bronze Age suggests that social and political factors had an impact on childhood stress during the later periods. There is no evidence that living at any one site resulted in a better quality of life.

This research has shown that if a study uses only LEH data, bigger picture seen in the Wilson band data may be missing. It may be assumed that the quality of life may be better during the rule of large empires and worse during periods of drier climate, however this research shows that social factors may have a bigger impact on childhood stress than climate.

Acknowledgements

I wish to thank my dissertation committee for all of their encouragement and support. I am eternally appreciative of my dissertation advisor, Dr. Jerome Rose, because this research would not have been possible without his guidance. From that cold November afternoon of our first meeting when he showed me a collection of teeth from an abandoned research project to the concluding word of this dissertation, he has generously offered his knowledge of microscopy, thin sectioning, childhood stress, Wilson bands, and teeth. I am appreciative of Dr. J. Michael Plavcan and Dr. Justin Nolan for their patience and helpful advice.

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I must express my gratitude to the King Fahd Center for Middle East Studies for their support throughout my studies at Arkansas. The Center not only made it possible for me to leave the university for a semester to do research in Jordan, but also provided a generous travel grant that allowed me to travel between ACOR and Yarmouk University to conduct my research.

I would like to thank my undergraduate advisor, Dr. Mark Taylor, for his advice and guidance before I decided to undertake this journey. He was right. It has been the most difficult and rewarding thing I have ever done. I am forever indebted to Ms. Mary Manhein for encouraging me to pursue a doctorate and giving invaluable advise throughout the entire process.

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Dedication

This research is dedicated to all of the people of Jordan…Past, present, and future.

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Chapter One – Introduction

1.1 Introduction

Bioarchaeology is the study of people in the past through skeletal analysis. Historically, the discipline was purely descriptive and yielded lengthy osteological reports are void of broader interpretations. The field underwent a transformation when osteological reports were brought out of the appendices of archaeological reports and were used as analytical tools to help answer the broader socio-cultural questions of archaeological studies (Buikstra, 1991). A focus on the biocultural approach to bioarchaeology sets the foundation for understanding people of the past in their place and time. The biocultural approach explores the various aspects of populations adapting to their environment through biology and culture.

The dramatic cooling and drying of the Levant during the Younger Dryas period is believed to be a contributing factor in the Levantine shift to agricultural subsistence (Munro, 2003). The Younger Dryas was a rapid cooling that followed a period of gradual warming after the last great Ice Age. The speed at which this climatic event changed the temperature across much of the earth meant that the human populations dependent on warm weather food sources needed to find another more stable subsistence strategy. Environmental pressures on human populations result in both biological and cultural changes as these groups adapted to ensure continued existence.

As the transition to agriculture and sedentary living helped to solve the problem of unstable food sources, these new ways of life come with biological consequences. To maximize the efficiency of the labor to calorie ratio, complex carbohydrates were cultivated. Fields of carbohydrate rich grains and cereals can feed larger populations. The shift to agriculture is responsible for what is known as the first epidemiological transition that resulted in increased infectious diseases associated with more people living closer together, a jump in zoonotic diseases from living closer to and coming into daily contact with domesticated animals, and increased mortality due to a lack of immunity to these new types of diseases (McNeill, 1976). Another important consequence of the transition to agriculture was the prevalence of nutritional deficiencies from eating a limited diet and carious lesions from the carbohydrate rich diets. With time populations were better able to cope with the consequences of this transition. The study of paleopathology in bioarchaeology has shown that these events can be seen in the skeletal record and the biocultural approach can be used to gain a better understanding of how people in the past adapted to changing environments (Armelagos, 2003; Buikstra, 1977; Larsen, 2000; Goodman and Leatherman, 2001; Ullinger et al., 2005; Zuckerman et al., 2011).

The area containing northwest Jordan includes both the northern plateau of the Jordan Highlands and the northern segment of the Jordan Valley. This region has a long and complex history that stems from its inclusion in the Fertile Crescent. It has seen periods of climate change, political transformation, and economic prosperity that have resulted in changes in population structures and economic strategies. While it was never the hub of any of the major ruling cultures in history, it is located at the crossroads to many of the most powerful governing bodies in the Levant's history (MacDonald et al., 2001).

1.2 Objectives

The objective of this research to gain a better understanding of how the rural communities, which provided the agricultural products important to the success of the larger cities, lived and adapted to their changing political and climatic environments. I am studying human teeth from burials at five archaeological cemeteries in northern Jordan that date from the Bronze Age to the Byzantine Empire. These cemeteries are the late Roman to Byzantine site of Sa'ad (Rose and Burke, 2004 a), the late Roman to Byzantine site of Yasileh, the Early Bronze

Age to Byzantine site of Ya'amun (El-Najjar, 2011), the Roman/Byzantine site of Natfieh (Al-Bashaireh et al., 2010, 2011), and Waqqas (excavated by the Department of Antiquities). The cemeteries have been previously excavated and documented by researchers from both Jordan and the United States. The excavations at Sa'ad, Yasileh, Ya'amun, and Natfieh are the result of a partnership between the King Fahd Center of Middle East Studies at the University of Arkansas and the Faculty of Archaeology and Anthropology at Yarmouk University in Jordan.

This research aims to gain a clearer picture of the health and overall quality of life for these various populations as a way to better understand how these groups are similar or how they differ across time and space. A comprehensive study of whether any of these populations had greater access to food or if there were periods of famine and hardship in the area during the Bronze Age to the end of the Byzantine Empire will be conducted. I will be focusing on finding evidence of repeated and periodic childhood stress found in teeth through discovery and identification of linear enamel hypoplasia (LEH) defects and accentuated striae of Retzius (Wilson bands). There is some evidence that epidemic diseases may have affected these areas during the times that the cemeteries were in use and this research should be able to contribute to the growing data on these occurrences (Conrad, 1994; Little, 2007). The tombs at these sites are difficult to date because of the history of tomb reuse (Al-Shorman, 2006 a) and looting throughout their history. It will be necessary to reassign the excavated tombs to their proper chronological position which has been made easier by the recent radiocarbon dating of tombs (Al-Bashaireh et al., 2011), the ability to date scarabs (Eggler, 2011) and lamps (Lapp, 1961) found within the tombs, and a study of their relative location in the cemetery (Al-Shorman, 2004 a).

1.3 Hypotheses

Although it is impossible to know with absolute certainty the life experiences of the people of the Levant from the Bronze Age to the Byzantine, bioarchaeological investigations can bring us closer to understanding how their changing social and political environments affected them biologically. Using the biocultural approach, it is possible to examine the enamel of teeth and gain a look into the life histories of the rural agriculturalists during their childhoods. Although the enamel only gives a snapshot of early childhood and not the entire lifespan of the individual, the health of the children of any population can provide insights into nutrition, disease load, socio-political changes, and overall quality of life for the whole community. Using this bioarchaeological framework, this study will investigate the following hypotheses:

- **Hypothesis 1:** Children do not possess a fully developed immune system and are susceptible to adverse physiological changes that occur during important stages in their lives as related to nutrition and disease. It is predicted that repeated and periodic childhood stress will be prevalent for the individuals at all sites during more stressful periods of childhood including the nutritional consequences of weaning and the effects of childhood illness.

  Children in all communities past and present are more sensitive to changes to types and availability of food resources. The introduction of solid food during the weaning process is a major shift in nutrition during childhood. The shift from a nutritionally balanced diet of breast milk to a diet of solid food that may contain nutritional deficiencies can trigger growth related problems. Decreased mortality rates in early childhood for pre-industrial societies has been linked to longer periods of breastfeeding. However, weaning at later ages has been shown to only delay the nutritional consequences of weaning to later childhood. Because the age of weaning in any community is culturally constructed, these effects should be seen to increase at the culturally determined weaning age.

Breast milk enhances the child's immune system by transferring passive immunity from mother to child and another consequence of weaning is the removal of these important breast milk properties (Katzenberg et al., 1996). Although some of the transferred immunity is retained after weaning, the child's immune system is not fully developed and they are more susceptible to childhood diseases during this period.

- **Hypothesis 2:** Social, political, and religious transformations can have a physiological effect on children. When major cultural shifts occur, there can be dramatic changes to attitudes toward children, availability of resources, and culturally constructed life stages (e.g. the age at which weaning and labor activities begin). The area in which this research focuses saw multiple social transitions. It is predicted that childhood stress markers will occur in higher frequency during periods of social, political, and religious transformation even when the type of food production has not changed.

  Several nitrogen and carbon isotope analyses have been conducted on the sites in this study to reconstruct the dietary composition of the people in this region (Al-Bashaireh et al., 2010; Al-Shorman, 2004 b; King, 2001). These studies have shown that C_3 plants composed most of the diets at all of the sites and the importance of C_3 plants did not change from the Bronze Age to the Byzantine period. Varied dietary composition can be removed as a contributing variable to this study. It is then possible to take a closer look at other nutritional factors across sites and time periods.

- **Hypothesis 3:** The focal region of this study has been studied by climate researchers because of its proximity to the Fertile Crescent and geographic importance to several major civilizations. The known climatic shifts in the Levant from the Bronze Age into the Byzantine make it possible to study the effects of broad climate change on these communities, as they continuously inhabited these rural sites. I expect to see an increase of moderate physiological stress in individuals who lived during periods that were warmer and drier as food resources become less abundant. Average levels of physiological stress will then decrease as the climate shifts to wetter and cooler periods that result in higher crop yields.

  The nature of cemeteries at these sites does not allow for exact dating of many of the individuals in this study. However, tomb dating methods have allowed for individuals to be placed into broad time periods (e.g. Middle/Late Bronze Age, Iron Age, Roman period, Late Roman/Early Byzantine period, and Late Byzantine period). Previous research into climate change in the Levant during these periods of time allow for comparisons between these broader socio-politically based periods (Alakkam, 2002; Issar and Zohar, 2010; Kaniewski et al., 2013; Rosen, 2007).

- **Hypothesis 4:** Some believe that these rural agriculturalists were poor and undernourished because they were forced to give all of their products to the larger cities and forfeit much of the earnings to taxes, but archaeological evidence has shown that this is unlikely (Rose et al., 2011). Using the test of overall quality of life, it is possible to test this assumption and discover the reality of whether the children were thriving. I expect to see evidence contradicting the assumption that these rural sites were inhabited and worked by people who were subservient to the ruling cities to the point that they were poor and undernourished.

Previous osteological examinations of the skeletal record from these sites have shown moderate levels of childhood stress and degenerative joint disease, but lower levels of infant mortality and pathological lesions associated with widespread ill health (Al-Asaqheirin, 2000; Al-Muheisen and El-Najjar, 1994; Al-Shorman, 2008; El-Najjar and Barnes, 2011; Rose and Burke, 2004 a). Building on these studies, this research will synthesize the overall quality of life for these rural agriculturalists by investigating the histological record of childhood stress.

1.4 Significance

Although site reports have been completed for most of the sites, the skeletal remains have not received comprehensive study. The absence of an across site synthesis provides this research with the opportunity to study the overall health of these rural agricultural communities in northern Jordan that have previously not received much consideration. Combining what is already known about these sites, people, and time periods with an analysis of the incidence childhood stress visible in dental enamel it is possible to test some of the assumptions held about this region. By using a biocultural perspective it is possible to examine whether some of the principles and generalizations seen in the archaeological and bioarchaeological record hold true for the communities of this study. By acquiring a broader understanding of how climate, politics, and disease shaped the lives of these rural farmers, we can gain insight into how present and future environmental and socio-cultural factors will affect the health of people across the world.

1.5 Organization of Chapters

Chapter two provides an overview of the archaeological and historical background of the portion of the Levant important to this study from the Bronze Age to the Byzantine Era.

The chapter gives a regional overview and a summary of each site that includes its role in the region. The chapter also details the regions socio-political history, disease history, and paleo-climate profile.

Chapter three gives a summary of the current research and principles of physiological stress including its relationship to life stages, diseases, and overall quality of life. This chapter also includes a brief overview of dental development with a focus on enamel development during childhood. This chapter concludes with a description of how enamel defects are formed and detailed explanations of how and why linear enamel hypoplasias and Wilson bands are formed.

Chapter four provides details of the methods for sample collection and selection for this study. The chapter provides the specific methods for macroscopic examination, thin sectioning, histological examination, and recording of enamel defects. The chapter concludes with the procedures for determining the age at which each defect was created.

Chapter five presents the results of the statistical analyses and the graphical representation of the data. Each analysis and statement of the results is divided into pieces that address the hypotheses for the study. This chapter also provides a discussion of the hypotheses and interpretation of the results as they pertain to the greater questions of health and quality of life.

Chapter six provides a summary of the results and a reflection on the greater implications for the results of this study and how these rural communities fit into the global community. The chapter concludes with a discussion of ideas for future research and how the study of enamel defects can be used cross culturally to construct a comprehensive view of childhood stress across borders and time periods.

Chapter Two - Archaeological and Historical Background

2.1 Introduction

The region of interest in this study has a rich archaeological and historical record. All of the sites were a part of a lush and fertile area designated for the production of agricultural goods. Historically, archaeology has focused on the large and highly populated municipalities in order to gain an idea of how the ruling and rich members of societies lived. By looking at these smaller rural farming communities that produced the food to support the larger cities, it is possible to see how the non-elite lived and died.

2.2 Sites

The five sites for this study were selected for their proximity to one another and the length of their occupation. The oldest documented tombs are from the Middle Bronze Age when collective tombs possibly used as family crypts were common and Egyptian artifacts were found as grave goods (Al-Shorman, 2007). The newest tombs are dated to the end of the Byzantine Empire and were frequently found with Byzantine lamps and glass. All sites surround or are close to a large wadi or another type of major water source. A wadi is a dry riverbed that fills with water during periods of rain.

All of the sites are located close to at least one of the Decapolis cities and would have had direct trade and sales relationships with these major civic complexes. The Decapolis cities were established at the close of the Bronze Age in northern Jordan and southern Syria (Riedl, 2003). The Decapolis cities were autonomous entities, however they were brought together by their similar language, culture, and location. The Decapolis was in place until after the Islamic conquest when it is speculated that political and climatic changes were responsible for its demise

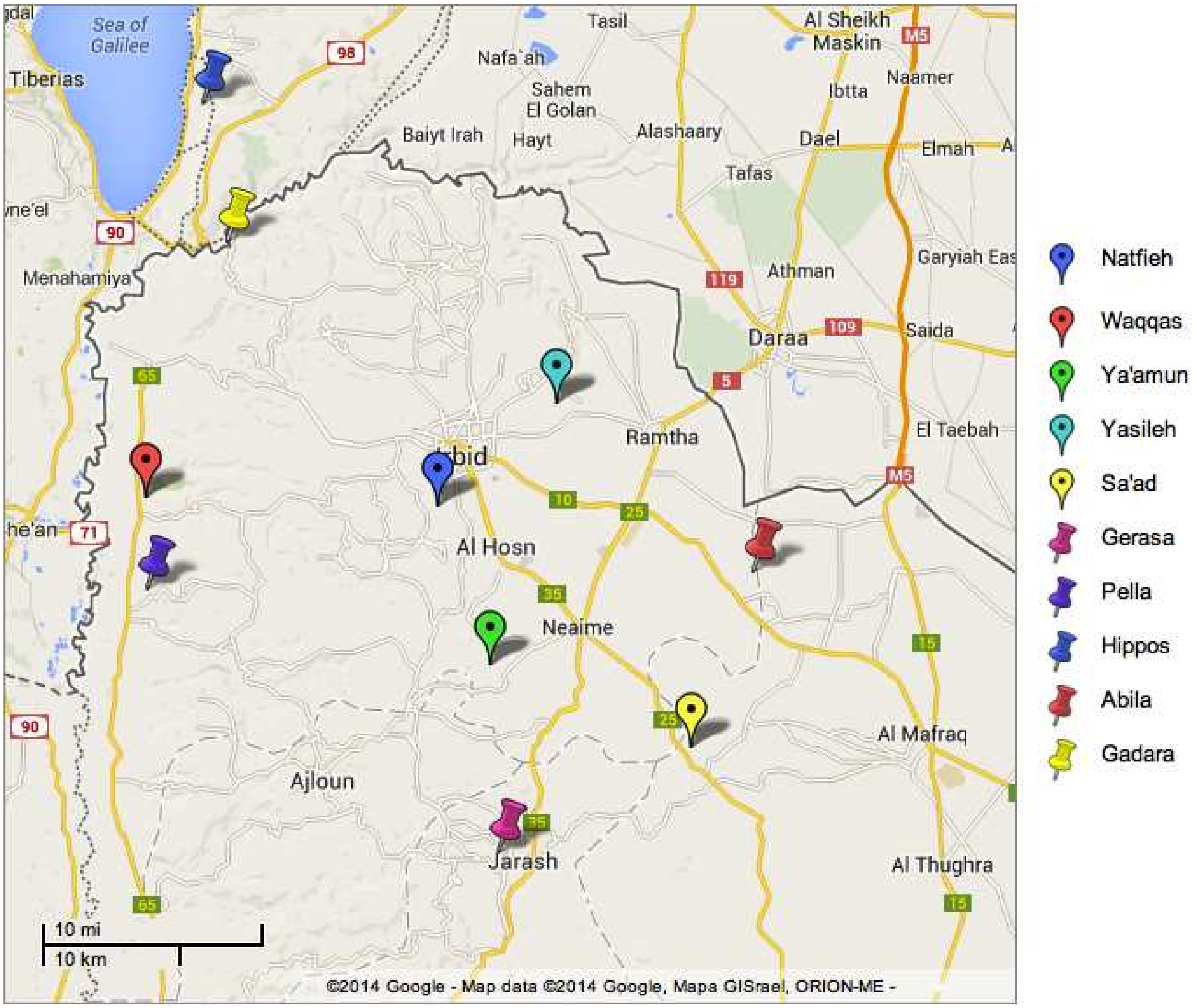


Figure 2.1: Map of archaeological sites in northern Jordan showing modern settlements and roads. Colored pointer icons designate sites included in this study and the cities of the Decapolis are designated by colored pushpins. (Map generated by Google Maps)

(Lucke et al., 2005). This is also the time when most of the sites in this study were also abandoned.

2.2.1 Sa’ad

The Late Roman/Byzantine site of Sa’ad is in the Northeastern region of Jordan. The site is about 15km east of the ancient site of Gerasa (Jerash), a Decapolis city that held jurisdiction over the area that included Sa’ad during the Roman and Byzantine eras. Sa’ad is located near major ancient trade routes for Syria, Jordan, Palestine, and Egypt (Rose and Burke, 2004 a). The soil at the site is mineral rich and ideal for agriculture. Even today the land is used for the planting of wheat and grapes as well as the cultivation of olive and fig trees. The proximity to Gerasa and the trade routes would have given Sa'ad the opportunity to sell and trade the consumables that their rich farmland produced.

Sa'ad was first surveyed in the summer of 1994 by a group of scholars directed by Professor Salih Sari from the Faculty of Archaeology and Anthropology at Yarmouk University (Rose and Burke, 2004 a). An agreement was made between the University of Arkansas and Yarmouk University to undertake a joint field school to train both American and Jordanian students in skeletal excavations. Excavations that were conducted for three summer seasons between 1995 and 1997 were led by Professor Sari and Professor Mahmoud El-Najjar from Yarmouk University and Professor Jerome C. Rose from the University of Arkansas (Rose et al., 1997; Sari and Rose, 1995). The excavations and skeletal analysis were jointly funded by the King Fahd Center for Middle East Studies at the University of Arkansas and the Faculty of Archaeology and Anthropology at Yarmouk University (Rose and Burke, 2004 a). Four necropolises were identified for excavation and mapping. Each necropolis contained narrow horizontal shaft tombs designed for one individual or larger tombs designed for multiple individuals.

The first evidence of occupation at the site is from the Roman period, but the site was occupied through the Early Islamic period. Only tombs and skeletons represent the Roman period at Sa'ad. The absence of crosses in the burial jewelry and children younger than 2 years of age confirms that these burials are representative of the pre-Christian inhabitants (Rose and Burke, 2004 b). The skeletal analysis of these Late Roman skeletons showed that the inhabitants were of general good health with no infectious lesions and a diet of mostly plant based foods and small amounts of meat and dairy products. The quality and quantity of the jewelry found within the tombs shows that the people of Sa’ad had some wealth (Rose and Burke, 2004 b). This suggests that the inhabitants were acquiring wealth from their rural economic activities such as agricultural trade.

This site is unique because it represents a period of major political and religious change to the region. The transition to Christianity during the Byzantine Era brought with it changes to burial practices and the construction of churches. A trade relationship with Gerasa is supported by the presence of large capacity wine presses at Sa’ad. Tomb reuse and emptying of tombs was popular during the Byzantine period (Rose and Burke, 2004 b). The skeletons from the remaining tombs have been dated using lamps and lamp fragments to the Late Byzantine. Isotope analysis of the skeletons from both the Roman and Byzantine skeletons at Sa’ad shows that they had the same diet composition, however where the Romans were all eating the same proportions of plant material to meat, some of the Byzantines had a higher ratio of animal protein to plant fiber consumption than other individuals living in Sa’ad during the same time (Rose and Burke, 2004 b). Howerever, high enamel hypoplasia rates are seen in the Byzantine skeletons suggest that the higher ratio of animal protein was not sufficient. The high LEH rates are indicative of childhood stress such as insufficient protein intake combined with epidemic disease (Williams et al., 2004).

2.2.2 Ya’amun

Ya’amun is an archaeological site that was inhabited for a long period of time and represents continuous occupation from the Early Bronze Age into the Islamic period. It is located about 25km southeast of the modern city of Irbid (El-Najjar, 2011). The site is just east of the ancient city of Arbela (now Irbid) and in close proximity to several Decapolis cities (Rose et al., 2011). A collaborative bioarcheological field school made up of Yarmouk

University led by Professor Mahmoud El-Najjar and the University of Arkansas led by Professor Jerome C. Rose conducted excavations at Ya'amun between 1999 and 2003.

The archaeological investigations at Ya'amun show a site that has a complex trade history and economic situation. Ya'amun is located within a nutrient rich agricultural plain. The site contains four wine presses that were used in commercial wine production (Rose et al., 2011). Due to the long period of occupation, there are a variety of tomb types, locations, orientations, and sizes. Most of the tombs from Ya'amun are dated to the Late Roman and Byzantine periods (Al-Bataineh et al., 2011 b). Rose et al. (2011) noted that the tombs are of varying quality and may represent differential economic status of those buried in the

Figure 2.2: A photograph of the northern fields of the site of Ya'amun in the spring of 2013. (Photograph by Teresa Wilson)

tombs. The Bronze Age is a unique time in the Levant because the Egyptian Empire has extended its influence into this region (Falconer, 2001; Strange, 2001).

This site is of particular interest because it does represent a large span of time and can be used to compare changes in childhood health over time and in same location. A study conducted by Alrousan (2011) shows a transition in diet during the Late Bronze Age that correlates with a shift toward a drier climate in the region. El-Najjar and Barnes (2011) saw a small number of pathological lesions other than the expected levels of osteoarthritis in the skeletons at Ya'amun. There is no evidence for chronic infectious disease and the frequency of enamel hypoplasias indicates only low to moderate childhood stress and good overall childhood nutrition (Rose et al., 2011). The analysis of the skeletal pathologies conducted by Al-Obeidat (2002) showed that the people of Ya'amun displayed levels of degenerative joint disease that are common in rural agriculturalists.

2.2.3 Yasileh

The Roman/Byzantine site of Yasileh is located 9km east of the modern city of Irbid at a crossroads between Syria, Palestine, and the rest of Jordan (Rose et al., 2011). This places the site close to the ancient Decapolis cities of Capitolis and Abila. Al-Shorman (2004 a) notes that the site had high levels of rainfall and rainwater was controlled by water reservoirs, irrigation channels, and a dam. Due to this large amount of rainfall the surrounding land was ideal for agriculture (Rose et al., 2011).

Most of the site including the church, settlement structures, and some of the tombs was excavated between 1988 and 1991 by Yarmouk University led by Professor Zeidoun Al-Muheisen in cooperation with the Department of Antiquities of Jordan (Al-Muheisen, 1989, 1992). However, only 20 of the identified tombs were excavated. A joint University of Arkansas and Yarmouk University bioarchaeological field school did excavations of the remaining tombs in 1998. All excavated tombs have been dated from the Late Roman and Byzantine periods (Al-Muheisen and El-Najjar, 1994).

Al-Muheisen and El-Najjar (1994) noted an overall lack of pathological lesions with the exception of instances of degenerative joint disease like osteoarthritic lipping of the vertebrae and joints. They also identified moderate childhood stress in the form of enamel hypoplasias, however infant and young child mortality was lower than contemporaneous samples and may suggest prevalence of childhood disease and seasonal variation in diet. Extensive tooth wear and antemortem loss across all age groups at Yasileh is attributed to the processing of grains for bread using basalt grinders (Khwaileh, 1999). Rose et al. (2011) suggest that the high level of carious lesions seen at Yasileh can be ascribed to their dietary dependence on grains as well as their ability to purchase sugary products.

Figure 2.3: A photograph of the site of Yasileh in 2013. The site includes the fields surrounding the wadi and the tombs were located along the sides of the cliffs to the east of the fields. (Photograph by Teresa Wilson)

Yasileh was a large town that supported the dietary needs surrounding large city centers. Its large size has allowed for a few unique characteristics that set it apart from the other sites. A wine press was excavated from near the Byzantine church that is large enough to accommodate large-scale commercial wine production (Rose et al., 2011). Al-Shorman (2004 a) has identified a clear delineation between three cemeteries at Yasileh that are characterized by different time periods (the Roman feeling that death was polluting and should be kept away from the living population to the opposite Byzantine/Christian response where burials can be close to areas of activity) and socioeconomic differences (tombs crafted by highly skilled artisans as opposed to tombs that were only roughly carved out).

2.2.4 Natfieh

Natfieh is an archaeological site located 5km southwest of Irbid and is centrally located to the other four sites in this study. Excavations occurred between 2006 and 2007 as a joint bioarchaeological field school by Yarmouk University, the Department of Antiquities of Jordan, and the University of Arkansas. The site was occupied from the Neolithic through the Islamic periods, however it experienced its highest population density between the Hellenistic and early Islamic periods (Al-Bashaireh et al., 2011). The inhabitants of Natfieh, particularly during the Roman and Byzantine periods, would have relied heavily on their own agricultural and pastoral activities to support their population (Al-Bashaireh et al., 2010).

A radiocarbon dating study was conducted of six tombs that showed that the skeletons were buried during the Late Roman and Byzantine periods (Al-Bashaireh et al., 2011). A reconstruction of the diet of the people of Natfieh by Al-Bashaireh et al. (2010) shows that their diet consisted of locally produced grains and animal proteins. Al-Bashaireh et al. (2010) point to historical documentation of the typical Roman diet of grains and highlight the fact that the citizens of Natfieh would have been cut off from the major trade routes thus making access to foreign food products and coastal fish improbable. Extensive looting, tomb disturbances, and diagenesis have made the skeletal elements fragmentary and heavily corroded. The overall preservation of the skeletal remains in the tombs of Natfieh is poor and detailed skeletal analysis is difficult and often impossible.

Figure 2.4: A photograph of the eastern part of the site of Natfieh in the spring of 2013. The boundaries of the site extend up either side of the wadi. (Photograph by Teresa Wilson)

2.2.5 Waqqas

The archaeological site of Waqqas is in the Jordan Valley near the western most boundary of Jordan and is located about 45km to the West of the modern city of Irbid. The site has been the focus two archaeological surveys (Glueck et al., 1951; Ibrahim et al., 1976) that identified Waqqas as an endangered site that was being encroached on by modern villages. The Irbid branch of the Department of Antiquities of Jordan conducted excavations of the site in

1999. Two necropolises were excavated and a total of 171 tombs were documented (Al-Asaqheirin, 2000). Necropolis one was in use during the Late Roman period and necropolis two was used during the Byzantine Era. Analysis of the dental remains by Al-Asaqheirin (2000) showed that the majority of the people buried in the cemetery were younger than 20 years of age and the reduced number of carious lesions in the later period reveals that the Byzantine inhabitants consumed a diet with fewer carbohydrates.

2.3 Social and Political History

The introduction of new social systems, political structures, and religious practices can have a huge impact on any group of people. The social, political, and religious changes in the region have extensive historical documentation. Especially during the Roman and Byzantine periods when detailed written records were kept, it is possible to know when certain events occurred. With accurate dating of the tombs, individuals can be identified that would have experienced childhood during these transitions.

A major political and religious shift occurred at the start of the Hellenistic Period. During this period, an increased importance is placed on the afterlife and sarcophagi and grave goods are common (Al-Shorman, 2007). Another change occurred as the Roman Empire stretched deeper into the Near East. In the Greco-Roman philosophies of death, it was believed that death was permanent and the soul died with the body (Davies, 1999). The funerary practices of Romans were based on the fact that death was polluting and swift burial was necessary (Toynbee, 1971). Al-Shorman (2007) notes that this belief in the polluted dead led to burials outside of the city walls and away from the general public. With the adoption of Christianity by the Byzantine emperor Constantine, another major change came to the people of the Levant. At this time, Christian feelings toward death caused adjustment to tomb location and burial practices. The appearance of churches within or close proximity to the city was followed by burials and catacombs located on the church grounds bringing the dead closer to living community (Toynbee, 1971). There is also a difference in living social status within the burials of this time period in the form of tomb location and architecture (Al-Shorman, 2007).

Social and political changes do not only affect nutrition, but also have an effect on the population composition. Ullinger et al. (2005) have shown that the emergence of a new ethnicity in the Levant following the Bronze Age in response to the immigration of people into the area. This area is also susceptible to the long distance transmission of disease because it was a hub for trade among some of the most powerful groups in the world. Trade between western Asia and Europe had to pass through this part of the world. The influx of people allowed for the introduction of diseases never experienced before like plague and other communicable diseases in which the population had no prior immunity.

Table 2.1: The socio-political phases and time periods in which the sites of this study were inhabited.

Socio-Political Phases	**Time Periods**	**Occupied Sites**
Middle – Late Bronze Age	2,000 BC – 1,200 BC	Ya’amun
Iron Age	1,200 BC – 332 BC	Ya’amun
Hellenistic	332 BC – 63 BC	Ya’amun, Natfieh
Roman Empire	63 BC – 324 AD	Sa’ad, Ya’amun, Yasileh, Natfieh, Waqqas
Byzantine Empire	324 AD – 640 AD	Sa’ad, Ya’amun, Yasileh, Natfieh, Waqqas

2.4 Disease History

Periodic and repeated childhood stress can be seen in the wake of widespread chronic and epidemic disease. As the populations of the Levant grew in size there was invariably a decline of sanitation due to larger numbers of people living closer together. Diseases and illnesses associated with poor sanitation and large numbers of people living in a small area like diarrhea and viral illnesses would have been important contributors to periodic childhood stress (Stathakopoulos, 2004).

The evidence for various forms of epidemic disease, chronic illness, and plague is present in both the historical and archaeological record of the Levant. It is known that plague (the Plague of Justinian or bubonic plague) came in several waves through the area of the Decapolis (Conrad, 1994; Little, 2007; Egan et al., 2000; McNeill, 1976; Rosen, 2007). Due to the high morbidity and rapid mortality associated with the plague, it is difficult to see in the archaeological record because it does not leave pathological lesions on those who die. There is no direct evidence that the plague had a large impact on the people at these rural sites, however there are tombs that exhibit hasty burial that may contain victims of plague.

2.5 Levantine Climate Change

Changes in health during documented periods of climate change is possible in this region of study because there has been detailed study of the climate and rainfall in the Levant from the Neolithic to present day. Specific documentation of the climate changes in Northern Jordan (Alakkam, 2002), within Jordan (Shehadeh, 1985) and across the Near East (Issar and Zohar, 2010) has revealed both large scale change across hundreds of years and small scale drought-wet seasonal cycles. Due to these specific studies, it is possible to match the people at the study sites to their climatic conditions for comparison. This requires accurate dating of all tombs.

The effects of climate on the overall health of a population has been shown when subsistence strategies must be changed to support the population like the shift to agricultural in the Americas (Steckel and Rose, 2005) and Japan (Temple, 2009). Rosen (1993) has identified the presence of nomadic pastoral camps in the Roman-Byzantine Levant that developed in response to the desertification of parts of Jordan. The major disruption at the end of the Bronze Age in the eastern Mediterranean that led to rapid changes in politics and religion, also known as the “Bronze Age Crisis,” has been linked to the rapid climate change leaving many areas drier (Kaniewski et al., 2013; Riehl et al., 2008). Lucke et al. (2005) have evidence that a rapid desertification of Northern Jordan and Southern Syria may have caused the downfall and rapid abandonment of the Decapolis cities after the Islamic Conquest. However, the most of sites in this study experienced continued occupation into modern times with ongoing agricultural activities.

Investigations into the climatic history of the northwest region of Jordan have yielded clues into settlement patterns, population density, and overall health of the past inhabitants. This geographical region, referred to as the Irbid/North Jordan sector, has seen shifts in annual rainfall and temperature during the Holocene. Starting in the Early Bronze Age the climate shifted into a drier and warmer cycle concluded and the climate began to improve through the Late Bronze Age. This climatic shift contributed to large migration events in the Mediterranean and Near East (Issar and Zohar, 2010; Rosen, 2007). Increased rainfall and cooler average temperatures followed this period of warming and drying.

As the communities moved into the Roman and Byzantine periods, the average climate was wetter and cooler than the previous phase. There were no periods of long term drought during these periods, however there is evidence that there were fluctuations in rainfall from year to year (McCormick et al., 2012; Riehl, 2009; Rosen, 2007). The annual variations in rainfall may not have had a significant impact on the Roman and Byzantine Empires. Rosen (2007:151) notes “the impact of climate on empires is neither simple nor direct. In the case of empires, the support networks are broader, and the social and economic infrastructures are geared for absorbing a great deal of stress to the system.”

2.5.1 Regional Climate Research

A study using oxygen isotope analysis of teeth from four of the five sites in this study has shown a drier and warmer Middle Bronze Age when compared to the cooler and rainier Byzantine period (Alakkam, 2002). The analysis of oxygen isotopes that precipitated from the drinking water into the enamel of the inhabitants was used in conjunction with other research in lake levels, sediment deposits, lake sediments, archaeological evidence, archaeoclimate models, and historical records to show a relationship between climate and population patterns. The reconstruction of the climate shows a warm Middle Bronze Age with modest annual rainfall that resulted in a small number of communities living in areas close to major water sources. The Late Bronze Age saw an expansion and growth in the number of inhabited sites that correlates with more annual rainfall. The Iron Age and Hellenistic period had an increase in annual rainfall, however it experienced political instability that resulted in a drop in the number of inhabited sites. The beginning of the Roman period saw an increase in occupied sites that was facilitated by the highest annual rainfall. The Roman period was not only the wettest period in this study, but it was also the time with the largest number of occupied sites. Although the annual rainfall during the Byzantine period was less than that of the Roman period, it was still higher than that experienced during the Bronze Age.

2.6 Summary

The sites of Sa’ad, Ya’amun, Yasileh, Natfieh, and Waqqas were chosen for this study because they represent a unique sample in the archaeological record. The four sites in on the Jordan Plateau (Sa’ad, Ya’amun, Yasileh, and Natfieh) are characteristic of the rural agricultural efforts in the higher elevations of the Near East. Waqqas is situated in the Jordan Valley and gives a contrasting view of an agricultural community in the lower elevations along the Jordan River where intensive agriculture is still practiced in modern times. All of these sites are situated next to or wrap around a major water source. The sites on the Jordan Plateau are all strategically located near wadis where the soil is fertile and water is available during the rainy periods. Being next to the Jordan River, Waqqas has a constant source of water. The cliff sides of these wadis are composed of limestone that has been carved into in order to create tombs.

The excavations of the sites yielded individuals from the Bronze Age to the Byzantine Era. This limits the scope of this research to that almost 3000-year time span. The Iron Age and Hellenistic periods will not be included in the study because of a lack of skeletons from those time periods. The absence of Iron Age burials throughout the Levant has been noted but goes unexplained (Faust, 2004; Kletter, 2013). It is possible that the Iron Age inhabitants had a different burial norm that meant the graves were located in an as yet undiscovered location or the burials were reused in later periods resulting in obliteration of evidence for Iron Age burials. The Hellenistic period saw a decline in population in the Levant (Alakkam, 2002).

The role of politics, disease, and climate on the region has a large impact on the people who are the focus of this study. The changing politics and religions that occurred over the thousands of years encompassed in this research resulted in shifting beliefs in regards to life and death. Combine these social changes with a gradual shift from a drier climate to increased annual rainfall and a complex biocultural system emerges.

Chapter Three – Stress Theory and Dental Development

3.1 Introduction

Teeth have played an important part in investigations of health and nutrition since early dental surgeons searched for the causes of dental caries and John Rigden Mummery explored the differences between caries rates in hunter-gatherer and industrialized societies (Hillson and Rose, 2012). As the fields of bioarchaeology and dental pathology developed and grew, researchers were able to add analyses of dental remains to their methodological toolbox.

Dental tissues do not behave in the same manner as other skeletal tissue, which allows for specialized study of teeth in the bioarchaeological record. Dental enamel does not remodel and repair during a person's lifetime. The enamel of all permanent teeth were formed during childhood and represent a record of the health of the person has those layers of enamel were being made. This unique feature of enamel allows for the study of childhood stress without having a sample of juvenile skeletons. The absence or underrepresentation of children in the excavations of cemeteries which has been noted in bioarchaeological research (Djuric et al., 2011; Jackes, 2011; Lewis, 2007) poses a problem for the study of children and childhood experiences of the past. A record of childhood from just after birth to around 8 years old is present inside the enamel of every adult and allows for the study of childhood health experience in the absence of juvenile skeletons in a skeletal sample.

Stress has many physiological consequences including an impact on the amount and ways in which certain tissues grow and develop. The nature of enamel growth allows for the study of physiological childhood stress. This chapter gives a summary of the current understanding of stress theory and how physiological stress affects the body. An overview of the formation and etiology of dental defects follows a summary of dental development.

3.2 Physiological Stress

Stress can manifest as either a physiological or psychological state. However all types of stress can have adverse effects on the physiology of an individual. This is particularly true when a developing child is being stressed because it will affect the growth events. With an understanding of the causes and effects of stress on the body, bioarchaeologists can gain information about life history and the experiences of people in the past.

Hans Selye was the first use the term stress as it is known today and to popularize the study of stress (1974, 1976). Selye identified the body’s three phases of reaction to physiological stress. The first step is the *initiation* of the stress event, which then causes a *disturbance* to the system that will result in a *response* from the body. Selye characterized the general adaptation syndrome as how the body responds to a stress event. The first stage is alarm, where the individual initiates the fight or flight response when the body decides whether it will fight the stressor or try to remove itself from the stressor. The second step is resistance, where the body releases hormones that alter the function of some of the body systems as a reaction to the stressor. If the body is unable to cope with the stressor by the release of hormones, the person enters the final stage of exhaustion that is characterized by illness and death.

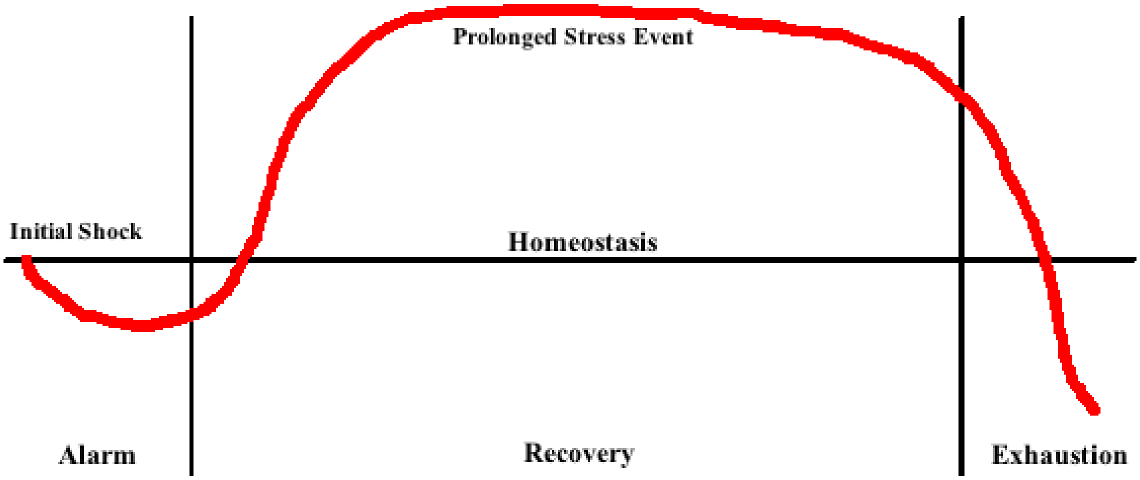


Figure 3.1: Selye's General Adaptation Syndrome. (Adapted from Selye, 1974)

The body exists in a delicate balance between anabolic and catabolic process (Aldwin, 2009). Anabolic processes build up tissues and organs to allow an organism to repair damaged tissues and grow new tissues like the deposition of enamel during development. Catabolic processes breakdown molecules to release the energy necessary to perform anabolic processes. The body must balance the breaking down of molecules so that enough energy is released to build up tissues without breaking down more than is necessary. This interaction between anabolism and catabolism is called metabolism. Stress can provoke a catabolic response through the release of hormones like cortisol and catecholamines.

Cortisol and catecholamines are catabolic stress mediators. Prolonged exposure to high levels of either of these hormones can result in decreased muscle mass and bone density. If the body experiences decreased muscle mass due to these stress mediators, the individual can experience increased frailty and decreased longevity. To combat the negative effects of repeated stress, the exposure of the individual to low levels of stress can result in non-lethal conditioning to future stress events, also called hormesis. This can be true for both conditioning to stress and immunization from certain diseases. If an individual experiences intermittent stress with periods of recovery between events, Aldwin et al. (2009) notes that the body has better catecholamine and cortisol patterns that lead to a spike in hormone release followed by a rapid return to homeostasis. If the body is not allowed to return to homeostasis after stress events and the event is continuous for long periods of time, the person will deplete their stress hormones and enter Selye's exhaustion stage. Aldwin also notes that if a person experiences chronic stress prior to exposure to a pathogen the resulting conditioning of the body may boost the body's immune response to the bacteria or virus. On the other hand if the stress events occur after a disease has compromised the immune system, the person's immune system may not be able to deal with both the stress and the pathogen resulting in failure to cope.

McEwen's (2008) study of the effects of stress and stress mediators on health and disease concluded that stress can have both a protective and damaging effect on the body. Building on Aldwin's models of stress, McEwen looks at the differences between acute stress and chronic stress from a biological viewpoint. During acute stress events, the body responds with major body systems like the cardiovascular, autonomic, immune, and metabolic systems, which promotes adaptation and survival. An immediate response to stress can quickly bring the body out of the stress event and into homeostasis. During chronic stress events, the body responds by taking functionality away from some body systems to place more energy into other body systems in order to increase the amount of resources being placed on fighting off the stressor. This impairment and strain placed on some of the body systems on a long-term basis can place stress on vital organs. McEwin says that this can cause systems like the cardiovascular system to become exhausted, which can lead to cardiac arrest.

Homeostasis is the body working to stay in a balanced state. Because there are multiple stressors including diseases, malnutrition, environmental, and psychological forces constantly being placed on humans, the body must achieve stability through changes to hormone levels. Although a body may achieve homeostasis, it may not be in a healthy condition. Homeostasis only ensures survival and not optimum health. Allostasis is the body's response to every day stress events to maintain homeostasis. An allostatic load is the amount of time and energy used to maintain homeostasis. McEwen (2008) points out that a high allostatic load can result in wear and tear to organ systems because an overload of stress can result in the body being unable to turn off allostasis.

The study of stress in bioarchaeology is limited to what can be seen on the skeletal remains. If a stress event was acute and minor, there may never be any skeletal indicators to suggest the person ever experienced stress. Common indictors of stress in bioarchaeology include the identification of cribra orbitalia, porotic hyperostosis, arrested long bone growth, and enamel defects (Buikstra and Ubelaker, 1994). Although it is widely believed that these pathological features indicate prolonged and repeated stress, some of the factors of their development are debated (Oxenham and Cavill, 2010; Walker et al., 2009).

3.2.1 Life Stages and Disease

Some childhood life stages like weaning can cause instances of physiological stress in the body. A study of juveniles at the Dakhleh Oasis in Egypt shows a weaning age of around 3 years old with weaning foods likely contributing to the presence of skeletal stress markers like cribra orbitalia and linear enamel hypoplasia (LEH) defects (Wheeler, 2012). Stable carbon isotope analysis conducted by Prowse et al. (2008) provides evidence that children were given complementary foods at a young age that explains the presence of poor dental health (carious lesions and heavy tooth wear) in young children in Imperial Rome. The stress caused by early introduction of solid food into their diet was a source of physiological stress on these children.

Enamel defects are non-specific indicators of stress, however it may be possible to detect disease and life stage changes if timings of the defects are closely considered. Sites like Tombos in Egypt (Buzon, 2006), the Roman city of Colonia lulia lader (modern day Zadar in Croatia) (Novak and Slaus, 2010), and post-medieval London (King et al., 2005) show evidence of disease causing physiological stress that shows itself in the skeletal record in the form of LEH defects, cribra orbitalia, and porotic hyperostosis. The literature on disease and chronic illness in this area gives very specific dates for possible occurrences that can compared to the timing of Wilson bands and LEHs (Conrad, 1994; McNeill, 1976; Stathakopoulos, 2004). If tombs of possible plague victims can be identified, there is a possibility for further testing to confirm the presence of plague. This would confirm plague was present and had an impact on these rural communities. Proper timing of the enamel defects can give an indication as to the age of the child when the stress occurred and give a better suggestion as to whether certain life stages in the children of these sites were causing more stress.

Bioarchaeologists have been interested in the relationship between childhood stress and decreased longevity of a population (Goodman and Armelagos, 1988; Vaupel, 1988). However it has been said that determining longevity and frailty from a skeletal sample is impossible because of the nature of the demographic composition of a cemetery (Wood et al., 1992). All of the skeletons in a cemetery are there because the people were unable to survive. Wood et al. (1992) posited that skeletal samples are made up of people with hidden heterogeneity of risk. These people have variable degrees of frailty that makes them either more resistant or more susceptible to disease and death.

The study done by Goodman and Armelagos (1988) looked at a skeleton sample from the Dickson Mounds that comprised three cultural horizons that encompass the shift to agriculture in the region. This study makes an important connection between childhood stress and decreased longevity of a population by identifying three processes that may have contributed to the results of the Dickson Mound sample. An increased lifelong biological susceptibility to illness may be the result of illness events during childhood. Not only can childhood illness make it easier for a person to contract infectious diseases into adulthood, but childhood illness may also make it more difficult for the individual to successfully respond to other kinds of stressors. Goodman and Armelagos also noted that behaviorally and culturally based activities could place children into contact with stressors at regular intervals. Although it may be impossible to determine the frailty of a population from a skeletal sample, it is possible to gain a better understanding of childhood health experiences as it relates to stress and longevity.

3.2.2 Quality of Life

Different patterns and frequency of physiological stress have been associated with dramatic changes in a society. Prolonged or repeated physiological stress can have an adverse effect on the quality of life of a population. An increase in the prevalence of enamel defects was shown in Mayan populations in Belize to be the result of the Spanish Conquest (Wright, 1990). Dental pathologies were shown to have increased following the transition from Roman Imperialism to the Middle Ages in Italy (Manzi et al., 1999). Dental research can give a view into social changes and the consequences of those changes on quality of life. It has been assumed that the inhabitants of these sites were poor and undernourished because of their status as farmers. If this assumption is correct, their overall quality of life should be low and evidence in the skeletal record.

Using the original skeletal analyses and examination of the dental defects, a clear picture of the overall quality of life for these rural communities can be established. It will be important to compare those sites that reside in the Jordan Plateau (Sa’ad, Ya’amun, Yasileh, and Natfieh) with the Jordan River Valley site of Waqqas to see if there are differences in quality of life that can be detected between these different environments. Children are more susceptible and physically impacted by systemic stress than adults. This differential susceptibility can be a useful guide to determining health in a community. A demographic study of the skeletons excavated at Natfieh show that most individuals died by the time they reached their 30s (Al-Shorman, 2008). Although this study does not include very many samples from this site, it will be important to evaluate the general quality of these individual's childhood to see if there may be a link between childhood stress and decreased longevity (Goodman and Armelagos, 1988).

3.3 Dental Development

According to Nanci's *Oral Histology* (2007), the development of dental tissues begins after 37 days of fetal development with the formation of a thickened band of epithelium around the mouth region. This primary epithelial band will make up the tissues of the upper and lower jaws. The tissues then begin to subdivide into the dental lamina and vestibular lamina. The dental lamina forms anteriorly in the mouth and develops epithelial outgrowths that indicate the positioning of the teeth.

After the fetus has organized the epithelial tissues, the development of the tooth germ commences. Although the process goes through several stages, development of the tooth germ is a continuous progression from start to finish. The bud stage occurs when the first epithelial cells move into the ectomesenchyme. The transition from the bud stage to the cap stage is characterized by the changes to morphological features of the cells. These morphological differences begin the process of differentiating the multiple tooth types. The cap stage is the condensation of the ectomesenchyme and the progression of the dental papilla into what will become the dentin and pulp. The enamel organ sites on top of the dental papilla like a cap, which is how the cap stage is distinguished from the bud stage. The tooth germ has begun to differentiate the various tissues and now consists of the enamel organ, dental papilla, and dental follicle. An enamel knot is a cluster of non-dividing epithelial cells that will coordinate the shape of the cusps. The bell stage is evident when the enamel organ resembles a bell. The bell shape is the result of the epithelial cap deepening under the enamel organ. At this point the tooth crowns assume their final shape. At this point odontogenesis and amelogenesis can commence the formation of dentin and enamel, respectively, around the mainframe that the tooth germ has created. The processes of odontogenesis and amelogenesis have reciprocal induction, which means that odontoblasts and ameloblasts must receive the signal of simultaneous initiation of enamel/dentin formation or the processes will not begin (Nanci, 2007).

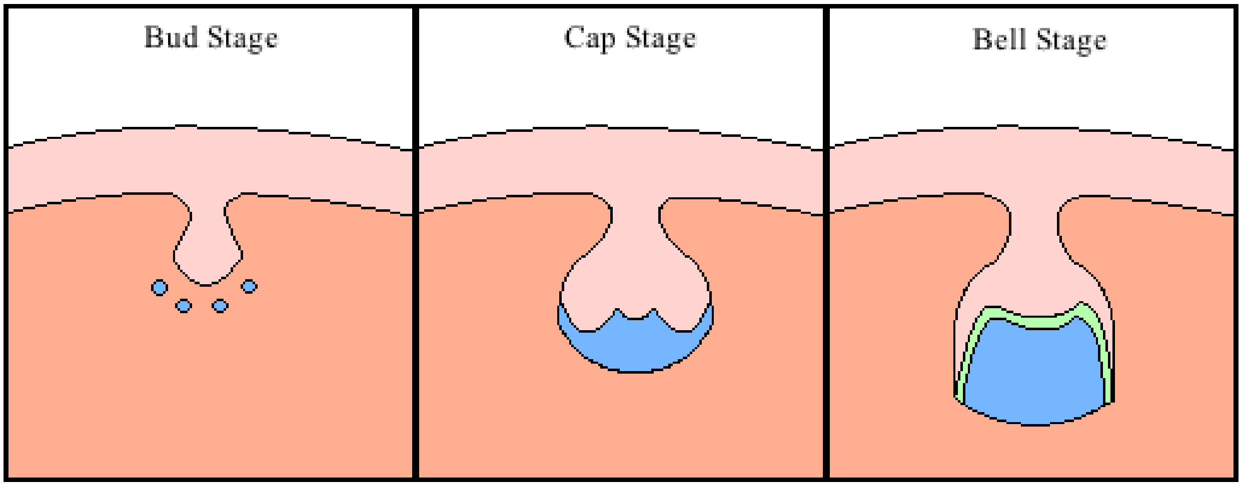


Figure 3.3: The stages of development of a tooth germ. (Adapted from Tucker and Sharpe, 2004)

Each tooth type develops at different times and rates (AlQahtani et al., 2010; Buikstra and Ubelaker, 1994). The initiation of tooth development begins soon after the formation of a fetus and continues until the last tooth is erupted from the gum line at around 21 years of age. The Atlas of Human Tooth Development and Eruption by AlQahtani et al. (2010) is a detailed chart of the timing and rate of dental development in from the study of radiographs of modern population from London. Although the sample that was used to create the atlas is modern and may not entirely represent populations of the past, the atlas is the most detailed and comprehensive atlas of tooth development that has been created and is useful for bioarchaeological research.

	Maxilla		**Mandible**	
Tooth	Alveolar Eruption	Full Eruption	Alveolar Eruption	Full Eruption
I^1	6.5	7.5	5.5	7.5
I^2	7.5	9.5	6.5	7.5
C	11.5	12.5	9.5	11.5
P^1	10.5	11.5	10.5	11.5
P^2	11.5	12.5	11.5	12.5
M^1	5.5	6.5	5.5	6.5
M^2	10.5	13.5	10.5	12.5
M^3	16.5	20.5	16.5	20.5

Table 3.1: The ages of alveolar and full eruption of the tooth types. (Adapted from AlQahtani et al., 2010)

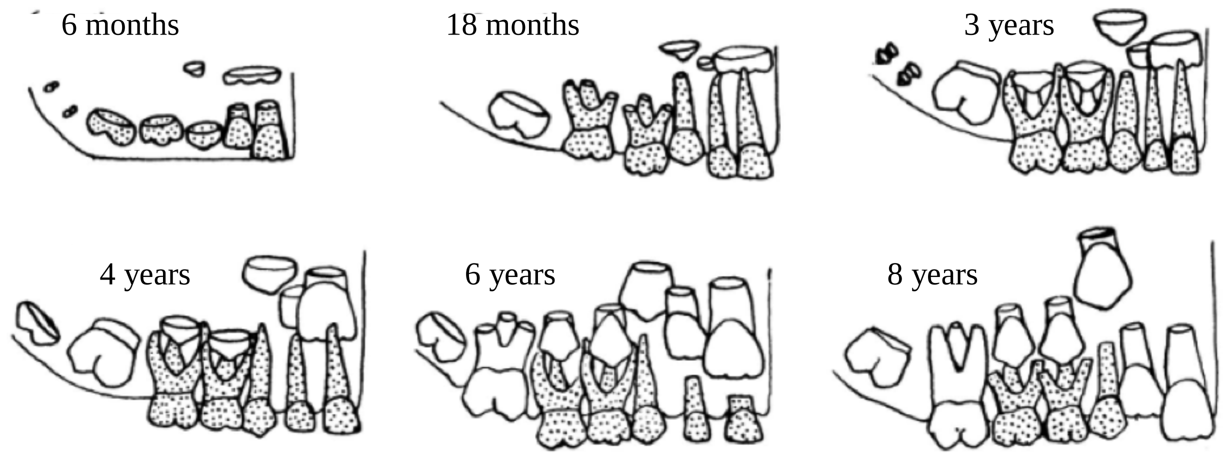


Figure 3.4: Developmental chart of deciduous and permanent dentition. (From Buikstra and Ubelaker, 1994)

3.3.1 Enamel Formation

Dental enamel is 96% mineral and 4% organic, which makes it hard, but brittle. In order to cut and grind food of varying consistencies that characterize the diets of humans, enamel needs to be hard and durable. However, the low percentage of organic matrix means that the enamel is also brittle and easily broken if unsupported. The dentin that underlies the enamel has a higher organic content and acts as a support for the enamel. The dentin support structure absorbs some of the forces that would otherwise break the enamel.

Enamel is structured as sets of parallel, stacked rods that do not have regular geometric shape. The rods are made up of grouped crystals that run the general direction of the rod. A rod sheath covers the rods and this area contains the organic material of the enamel. The rods are stacked with layers of crystals oriented in a different direction that is called the interrod. This rod-interrod matrix gives the enamel its stability.

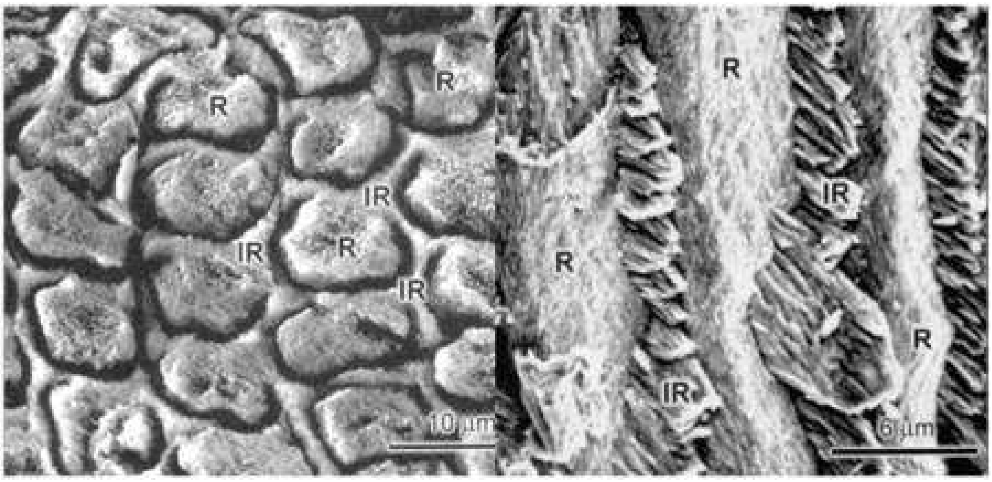


Figure 3.5: Two scanning electron microscope images of the rod (R) and interrod (IR) orientation and relationship. (From Nanci 2007)

The process of enamel formation is called amelogenesis. Ameloblasts are the cells that secrete the enamel during amelogenesis. The ameloblasts undergo progressive phenotypic changes throughout the amelogenesis process that reflect the stages of enamel formation. The three main functional stages of amelogenesis are the presecretory stage, the secretory stage, and maturation. In the presecretory stage, the ameloblasts differentiate to form independent cells. The ameloblasts change polarity so that the organelles are aligned for secretion. Each of the cells develops the protein synthesis apparatus that will provide the materials necessary to create enamel. The secretory stage of amelogenesis is the formative stage. The ameloblasts prepare the distal end of the cells (Tomes' processes) where the dentino-enamel junction (DEJ) forms for deposition of enamel. The mRNA for enamel proteins is translated by the ribosomes in the ameloblasts so that the enamel can be modified and packaged by the golgi complex. The packages of enamel protein are sent to the distal end of the cell where it is released against the dentin mantle or on top of already deposited enamel protein packets. The enamel proteins are not yet rods. The interrod structure is formed first to delimit the space around the rods. The final stage of maturation begins concurrently with the secretory stage so that the enamel proteins can be mineralized as new packets are laid down. The ameloblasts regulate and transport the ions that signal mineralization. Once the ameloblasts reach the end of their run, which will become the crown surface, the ameloblasts undergo apoptosis. Apoptosis, or self-destruction of cells, at the completion of amelogenesis is needed so that the ameloblasts do not continue to create enamel.

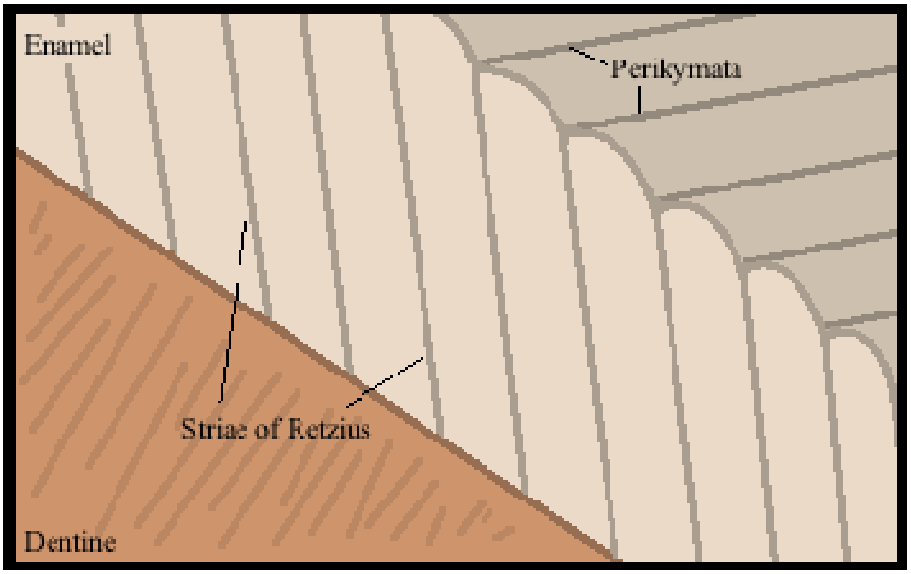


Figure 3.6: Diagram of a cross sectional cut of a tooth showing the striae of Retzius and perikymata. (Adapted from Nanci, 2007)

Amelogenesis begins at the cusps of each tooth. A group of ameloblasts will form a cervical band around the circumference of the tooth and move toward the top of the tooth as they lay down enamel. As one cohort of ameloblasts is excreting enamel, another cohort of ameloblasts will begin amelogenesis immediately below the previous cohort. Striae of Retzius are the lines that result from one cohort of ameloblasts laying enamel up against a previous amelogenesis cohort. The lines indicative of the striae of Retzius are structurally altered rods that form at the surface of an enamel layer and demarcate where the ameloblast cohorts traveled. Striae of Retzius have a weekly rhythm because amelogenesis occurs on a predictable schedule. The surface of the enamel is not smooth and contains grooves known as perikymata. Perikymata are the surface manifestations of the striae of Retzius and are the locations of ameloblast apoptosis.

There is also a feature of dental enamel called cross striations. These striations are seen as constrictions in the enamel where enamel formation has ceased and resumed. Cross striations demarcate the daily progression of rod formation because amelogenesis has a diurnal rhythmicity that means enamel is deposited at about 4 micrometers per day. Counting cross striations can be used to determine how long it took for the completion of amelogenesis. These incremental growth layers can be determined under microscopic examination by determining the number of cross striations (daily increments of about 6 to 10 days) occur between striae of Retzius (Antoine et al., 2009; Guatelli-Steinberg, 2010; Lacruz et al., 2011).

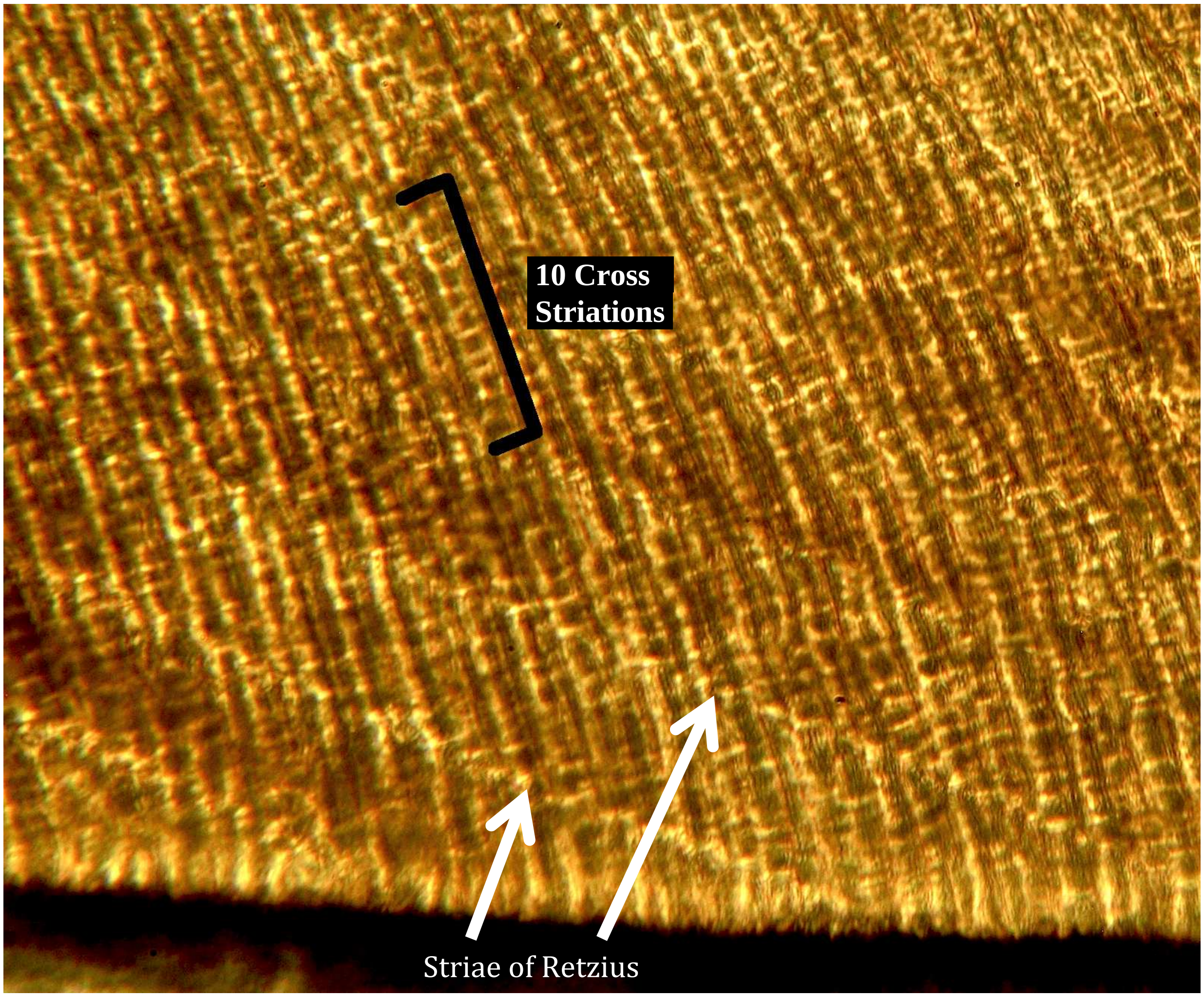


Figure 3.7: Micrograph of Tooth 11067 showing cross striations in between striae of Retizius. Ten cross striations are shown (bracket) indicating 10 days of growth. (Photograph by Teresa Wilson)

3.4 Enamel Defects

Enamel defects are the result of disruptions or alterations to the amelogenesis process. Amelogenesis is dependent on the body's ability to provide the amino acids necessary to create enamel proteins. If the body is unable to produce these proteins, enamel defects can result. The two major types of enamel defects are LEHs and Wilson bands. Although they are both the result of disturbances in enamel formation and can be found in the same location, there are different processes creating these defects. Physiological stress plays an important role in the formation of these enamel defects.

3.4.1. Linear Enamel Hypoplasias

Enamel hypoplasias are an enamel defect that manifest on the crown surface and can be classified as lines, pits, or grooves. Pit and groove form hypoplasias can have multiple etiologies that deal with genetics and trauma. The linear form (LEH) is the type of surface defect that is commonly used in bioarchaeology because it can represent a stress event. In bioarchaeological research, LEHs are counted for each tooth as part of the standards of data collection of a skeletal sample (Buikstra and Ubelaker, 1994). The interpretation of the LEH data is dependent on contextual knowledge of the sample and the research questions for the project.

LEHs are the result of systemic stress events like serious and prolonged illness in conjunction with severe nutritional deficiency. LEHs form as a consequence of incomplete amelogenesis. If the ameloblasts do not create a sufficient amount of enamel matrix due to amino acid deficiencies and disruption in protein synthesis, the ameloblasts will not travel the entire width of the enamel space. Because enamel formation starts at the cusp and concludes on the cemento-enamel junction (CEJ), the LEH begins at the first effected perikymata closest to the cusp. This marks the first cohort of ameloblasts that was unable to produce enough enamel to reach the surface of the crown. If the stress event continues or other stress events occur that do not allow for correction of the nutritional deficiency, then the LEH will continue through subsequent cohort ameloblasts. Once the ameloblasts begin to return to the correct enamel width, the nutritional deficiency has been corrected. This means that the end of the stress event is not marked by the last effect perikymata because this point is only the place where all ameloblasts are functioning properly again and not when the individual is starting to overcome the stress.

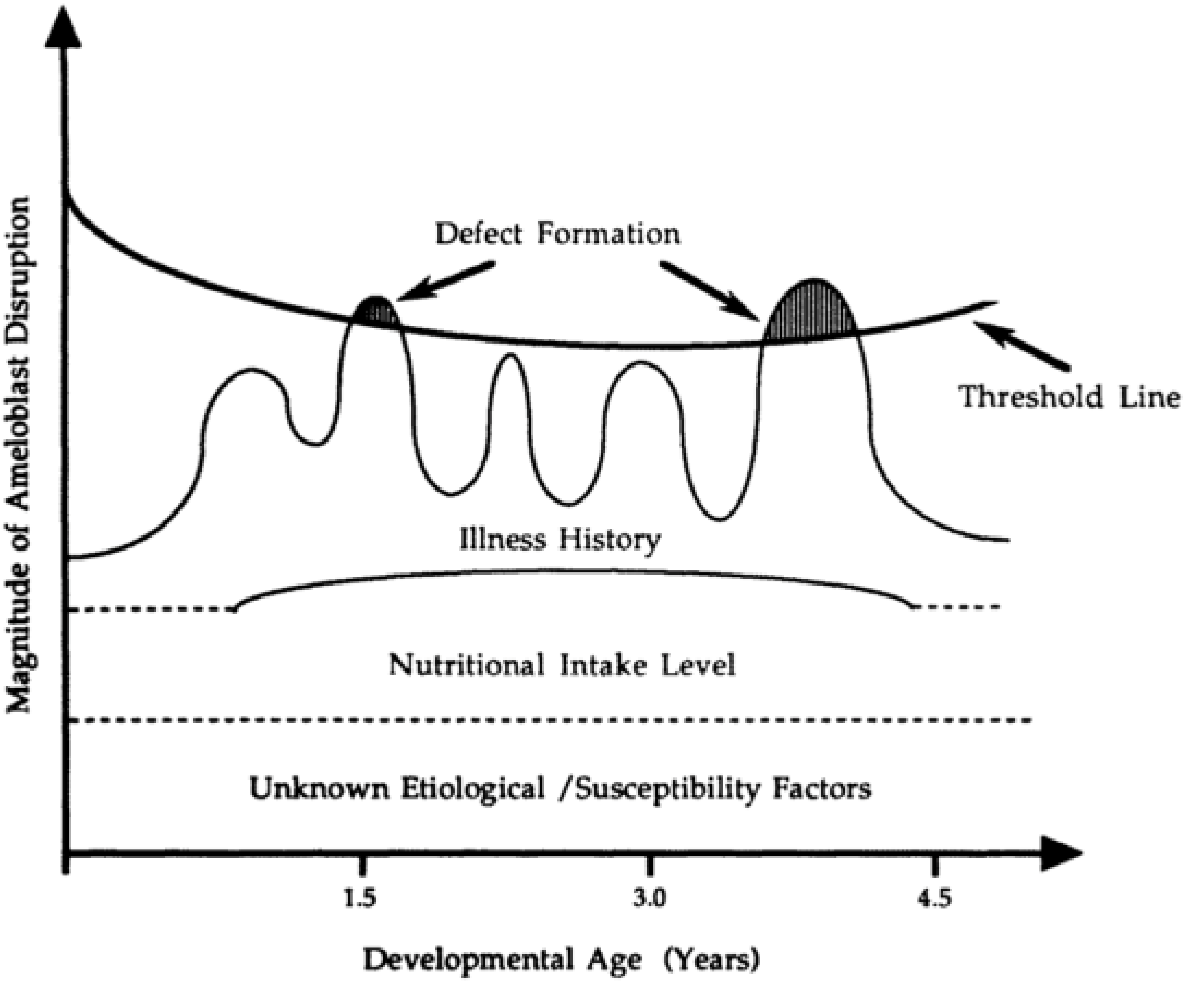


Figure 3.8: Threshold model for the formation of enamel defects. (From Goodman and Rose 1990)

Incisors and canines have been shown to be the most sensitive teeth to the processes that lead to LEHs (Condon and Rose, 1992; Goodman and Rose, 1990). The basic cylindrical shape of these tooth types mean that the paths of the ameloblasts are less elaborate as compared to multiple cusped teeth like premolars and molars (Hillson and Bond, 1997). Recording of LEHs is commonly done through macroscopic observation (Buikstra and Ubelaker, 1994), however no consensus exists as to whether this is the most accurate and efficient recording technique (Ensor and Irish, 1995; Hassett, 2012; Sabel et al., 2010; Witzel et al., 2008).

Although physiological factors that contribute to the formation of LEHs is well understood, it is still possible to misinterpret LEH data. In the King et al. (2005) study of London churches of Spitalfields and St. Brides, the researchers noted that the individuals that had larger numbers of short duration enamel defects may have had the same proportion of crown surface effected as those individuals with fewer but longer lasting stress events. It is possible to interpret these two hypothetical individuals as having the same stress history when they actually have two different stress profiles.

3.4.2. Wilson Bands

Striae of Retzius can take on a dark accentuated profile in histological examinations. These accentuated striae of Retzius are often referred to as Wilson bands. These unusual striae were identified as pathological bands that developed during amelogenesis (Wilson and Shroff, 1970). However they were renamed Wilson bands when it became apparent that these striae may not be pathological in nature (Rose et al., 1978). Wilson bands are the result of abnormal enamel rod structure along the striae of Retzius. The prisms within Wilson bands are oriented in a different direction than the surrounding prisms, which makes them appear dark under light microscopic examination. As the light passes through the normally oriented prisms the enamel appears light and transparent. When the same light passes through the Wilson bands, the shifted prisms appear dark and opaque because light cannot pass through them. They mark the location of the ameloblasts at the time of the stress event. Wilson bands do not always extend the entire width of the enamel.

Similar physiological processes are occurring in the formation of Wilson bands and LEH defects. However this study showed that Wilson bands are not always seen in association with LEHs. Wilson bands can represent brief periods of stress (1-5 days), which contrasts with the long-term incidents (weeks or months) needed to produce a LEH. It is important to note that the presence of a Wilson band does not mean that a disease was experienced (Rose et al., 1978). Stress can manifest in many forms and each individual can confront stressors differently. The analysis of Wilson bands can be used when diet is unaltered to study other factors effecting the population like political influences, diseases, and environmental changes. In a comparison of sites with similar diet, examinations of Wilson bands can also isolate possible differences in populations unrelated to diet.

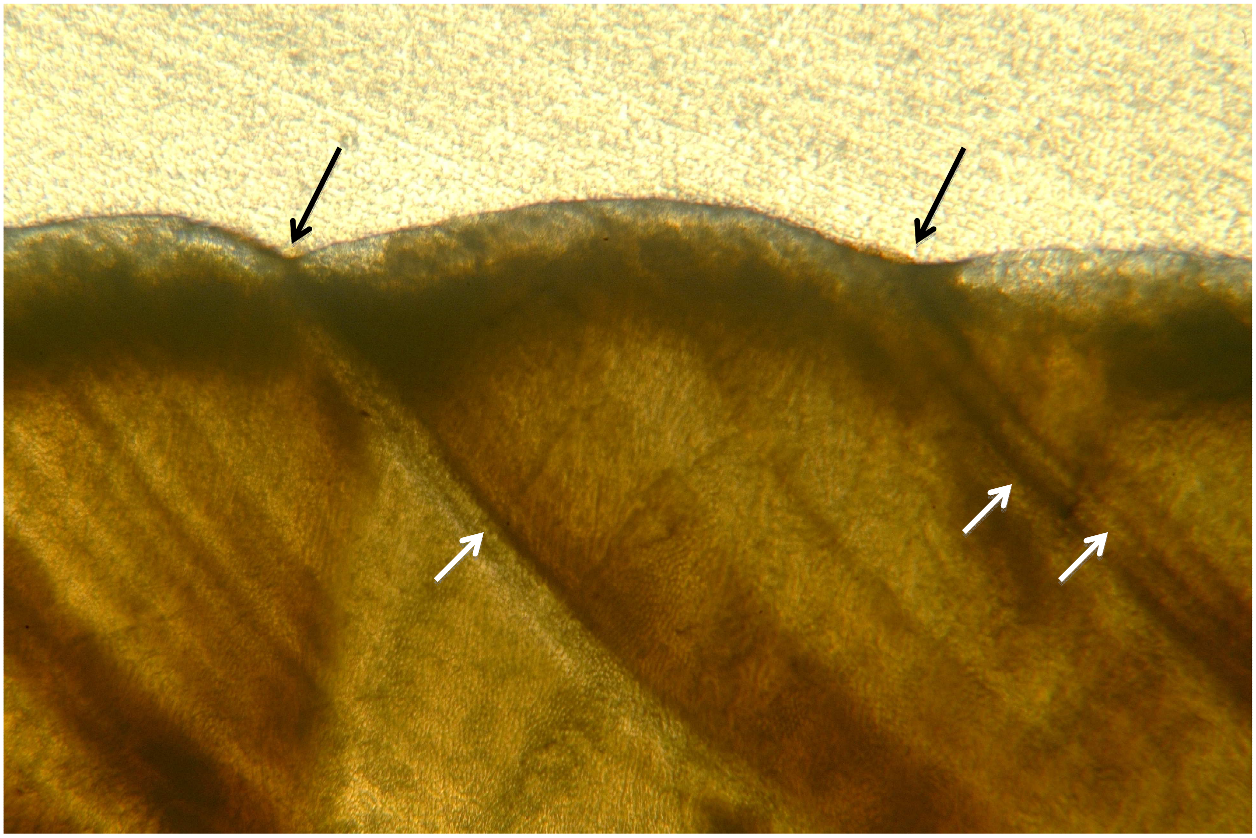


Figure 3.9: Micrograph of Tooth 11828 showing the association between LEHs (black arrows) and Wilson bands (white arrows). (Photograph by Teresa Wilson)

Condon and Rose (1992) identified that canines are more sensitive to the processes that produce Wilson bands as compared to premolars. By looking at the numbers and locations of Wilson bands form the same individual across tooth types, they were able to isolate canines as the most likely tooth type to exhibit the most Wilson bands. The criteria for Wilson band identification and recording is not standardized, however researchers has suggested the following conditions for identification: the Wilson band must have both buccal and lingual expression, the Wilson band must extend from the DEJ to the surface of the crown (or at least 75% of the enamel width), and the prisms within the band must have a different orientation than the surrounding prisms (Goodman and Rose, 1990; Rose et al., 1978; Wilson and Shroff, 1970; Witzel et al., 2008). As a sensitive indicator of childhood stress, Wilson bands can be used to see periods of widespread, new, or increased stress in a population. If there is a peak in the frequency and number of Wilson bands in a community, it could signal changing to stress events.

3.5. Summary

Although important to understanding the lives of people in the past, the study of stress in bioarchaeology is hindered by the absence of soft tissue evidence. Without being able to measure levels of the stress mediating hormones cortisol and catecholamine or examine the cardiovascular system for evidence of stress related impairment, bioarchaeologists must rely on skeletal indicators of stress to study childhood stress in the past.

The non-specific indicator of stress that is commonly recorded during osteological analyses are the number LEHs and their location on the tooth (Buikstra and Ubelaker, 1994). The ability to examine and record this indicator macroscopically means that it is accessible to all researchers. However, LEHs only represent severe nutritional deficiency episodes and cannot be used to determine less intense and shorter duration stress events.

Rose et al. (1978) noted in their study that Wilson bands can provide valuable information to bioarchaeologists. As an indicator of childhood stress, it is possible to take a glimpse into the early childhoods of a population. Children found in a cemetery were overstressed to the point of death and do not represent the stress profiles of the majority of the population that survived into adulthood. Histological studies of enamel defects can provide information about smaller stress events that cannot be detected when a researcher only uses surface defects as a gauge of systemic stress.

The analysis of enamel defects can provide a unique and detailed chronological record of a person’s stress experience during early childhood. Once enamel is laid down during amelogenesis, the only factor that can affect the developmental record is attrition at the cusp, which will destroy evidence of enamel defects that occurred very early in childhood. The study of enamel defects is unique because researchers do not need to have access to juvenile skeletons to be able to explore childhood stress.

Chapter Four - Materials and Methods

4.1 Introduction

In order to properly test the hypotheses proposed in this research, it is important to address the goals of the research in the methods of analysis. The sites and skeletons included in this study have already undergone various skeletal analyses, however a histological examination of the teeth has not been executed in previous research. The principal goal of this research is to gain a better understanding of childhood stress in these past populations. Teeth were chosen and collected in order to control for unwanted variables. This chapter establishes the protocol in which the samples were prepared and analyzed in order to achieve this goal. This research examines two types of enamel hypoplasia and this chapter details how each type of analysis was completed.

4.2 Sample Collection and Selection

The teeth in this study were gathered after the conclusion of the excavations at each site in Jordan. Initial selection of the teeth was based on preservation status, tooth type, and the time period in which the individual lived. Teeth were collected from the skeletal samples with emphasis on obtaining even numbers of tooth samples across the sites and time periods. However in the initial stages of collection, the highest priority was placed on teeth that had good preservation, only small amounts of attrition, and were of the correct tooth type.

Skeletal preservation at each of the sites was variable and often dependent on whether the tomb had been robbed and its proximity to water. Teeth with damaged or missing dentin were not excluded from the study because the only portion of the tooth that was studied was the enamel. If the enamel was broken into pieces that could not be reassembled while retaining the original shape and orientation of the enamel, the tooth was not collected for study. Those teeth that were etched or covered in foreign matter like concretions or dental plaque were collected for further examination for inclusion in the study. Teeth that exhibited heavy amounts of attrition were avoided because the information contained within the cusp region had been removed and the early childhood years would not have been visible.

The only tooth type utilized in this study was the permanent canine. One tooth from each individual or locus (in the case of multiple burials) was collected. Either the mandibular or maxillary canine was collected based on which of the teeth was present or had the best preservation. If preservation status was the same for both types of canines, priority was given to mandibular canines over the maxillary canines.

Canines were selected as the only tooth type for analysis in this study. Of all of the teeth, canines have been shown to be the most susceptible to the stressors that cause surface enamel defects (Condon and Rose, 1992). This study relies on the ability to detect enamel defects in the most possible places. Choosing a tooth type that consistently lacks enamel defects because it is not sensitive to certain types of stress would result in the absence of data. The development of canines spans the longest period of time of all of the teeth. The enamel of canines starts to develop within 4 months after birth and continue to develop until the child is about 6 years old. The longer the span of time that a tooth is developing can provide a longer snapshot of the individual's childhood. If tooth types with a smaller growth interval are chosen, the interval of childhood stress will be limited. Canines possess an enamel morphology that provides for less prism complexity at the cusp. The reduced complexity is due to canines only possessing one cusp with a circular transverse plane. Molars are less suited to histological studies of enamel defects because the multiple cusps on the occlusal surface causes the enamel prisms to be oriented at irregular angles to accommodate the extra cusps so that there are no gaps in the enamel.

After assessing the condition of each tooth and the proportions of teeth needed over the various time periods, 325 canines were found suitable for study (Table 1). Using the teeth available for study, samples for this study were selected in order to produce an even distribution over the time periods and to maximize the number of teeth collected per site. Unfortunately the preservation at Natfieh only allowed for six samples to be analyzed and the samples from Waqqas only come from one tomb due to limited availability of the skeletal material. Initially, 330 teeth were selected for analysis, however 5 needed to be removed from the sample due to mislabeling of the teeth during collection. There was no way to confirm the site or tomb number of these teeth, so determination of time period affiliation was also impossible. All excluded teeth were labeled as originating from the same site and tomb.

Table 4.1: Sample distribution by site and time period.

Time Period	**Ya'amun**	**Yasileh**	**Sa'ad**	**Waqqas**	**Natfieh**	**Total**
Mid/Late Bronze Age	116	0	0	0	0	116
Iron Age	1	0	0	0	0	1
Roman	32	50	30	15	0	127
Late Roman/Byzantine	15	0	1	0	5	21
Byzantine	40	0	19	0	1	60
Total by Site	204	50	50	15	6	325

All collected teeth were given a random five digit number for identification purposes. To ensure a blind study, the five digit number was the only identifying label to follow the teeth from initial examination to slide analysis. Site and time period were reconnected to the samples only after the histological analysis was complete and all data had been collected. This precaution was essential to guaranteeing that biases based on the study’s hypotheses were not present during data collection.

4.3 Macroscopic Examination

A final visual inspection was given to each tooth to confirm that it was suitable for histological study. The teeth were cleaned using ethyl alcohol (95%) as needed to remove excess dirt. The teeth were placed individually into small envelopes labeled with the tooth's unique identifying number before being prepared for photography.

After the teeth were completely dry, photographs of the labial surface of each canine was taken using a Nikon D70 and a lighting setup that allows for the casting of shadows across the tooth surface. Although previous researchers found it difficult to photograph enamel due to its highly reflective properties, proper lighting conditions make it possible to capture surface defects of the enamel without coating it with a matte substance. A camera mounted on a copy stand or a horizontally oriented tripod reduces the amount of vibration and blur experienced when taking photos by hand. In order to cast the proper shadows on the surface of the enamel, two light stands were equipped with daylight fluorescent bulbs. The light stands were placed on either side of the photograph surface so that both lights illuminated the tooth. One light stand was then angled down toward the apex so that the light no longer concentrated on the tooth, while the other light stand was angled up toward the cusp. Using indirect lighting that is coming from multiple directions casts shadows on the surface of the enamel where defects are present (see Figure 4.1). A series of photographs was taken for each tooth where the light stands were shifted either further or closer to the tooth to cast different types of shadows on the surface.

A photograph was selected from each photographic series that best depicted the enamel hypoplasias on the surface of the tooth. A photograph of the surface of the tooth serves as a record of the condition, features, and size of the tooth. This photographic record is important not only for the current study but also any future studies because the teeth were rendered unusable for other kinds of studies during the histological process. The resulting digital archive of the teeth in the study sample was then used to record the number and locations of the LEHs visible on the surface of the enamel. This information was used later to verify all LEHs were recorded in the microscopic examination.

Figure 4.1: Photograph of anterior view of Tooth 11850. (Photograph by Teresa Wilson)

4.4 Thin Sectioning

In order to perform histological sample of the collected teeth, the samples were thin sectioned and placed on glass slides. Thin sectioning of the samples was done using a modified version of the standard procedure for enamel histology outlined by Marks et al. (1996).

The embedding process starts with the construction of a small wire stand that allows the tooth to be suspended horizontally. Proper alignment of the tooth at this step is important to insure the later saw cuts create longitudinal labiolingual slices through the midsection of the canine. The tooth and stand are placed into a disposable Peel-A-Way mold and glued down so that the tooth and stand do not fall over. The epoxy used for embedding is the Buehler Epoxicure system (mixed using manufactures instructions). About 40-50 mL of mixed epoxy resin is needed for each tooth. The epoxy resin is poured directly over tooth inside the mold. If mixed properly the resin should contain minimal bubbles, however if an excessive number of bubbles are present it is necessary to place the sample in a vacuum desiccator to bring the bubbles to the surface. Curing of the epoxy varies depending on the manufacturer and epoxy used.

The teeth that were prepared and thin sectioned at Yarmouk University in Jordan were prepared in a similar process. Teeth were secured on wire stands and placed in Leco brand mold housings. The bottom caps of these cups have double-sided adhesive for securing the sample during embedding. The epoxy resin used for these samples was Araldite. Due to the nature of this epoxy, vacuum desiccation did not remove excess bubbles, so this step was skipped. The Araldite required 48 hours to fully cure. Once hardened, the bottom cap of the cup was removed and the epoxy block with embedded tooth was easily removed (see Figure 4.2). The Leco cups were cylindrical and produced round epoxy blocks (see Figure 4.3).

However the shape did not affect the mounting of the samples onto the thin section saw. Because the thin sectioned slides are cross sectional views that are rectangular and indistinguishable from the blocks produced by the Peel-a-Way molds.

Figure 4.2: Teeth secured inside Leco cups and embedded in Araldite epoxy resin. (Photograph by Teresa Wilson)

Figure 4.3: Tooth samples embedded in cured epoxy resin with round shape. (Photograph by Teresa Wilson)

Once cured, the sample is placed in a mounting chuck to be affixed to the Buehler Isomet Slow Speed Saw. A diamond wafering blade is used to make a cut that is slightly to the right of center through the sample. A frosted glass slide is glued directly to the cut surface still mounted to the saw and allowed to dry. The saw blade is then positioned to acquire a slice of about 0.4mm with the second pass of the blade. Once a center cut slide is achieved, the thin section can be etched with 1N HCl for 15 seconds. This removes the surface layer of damaged enamel prisms and allows the topography of the striae of Retzius to be revealed.

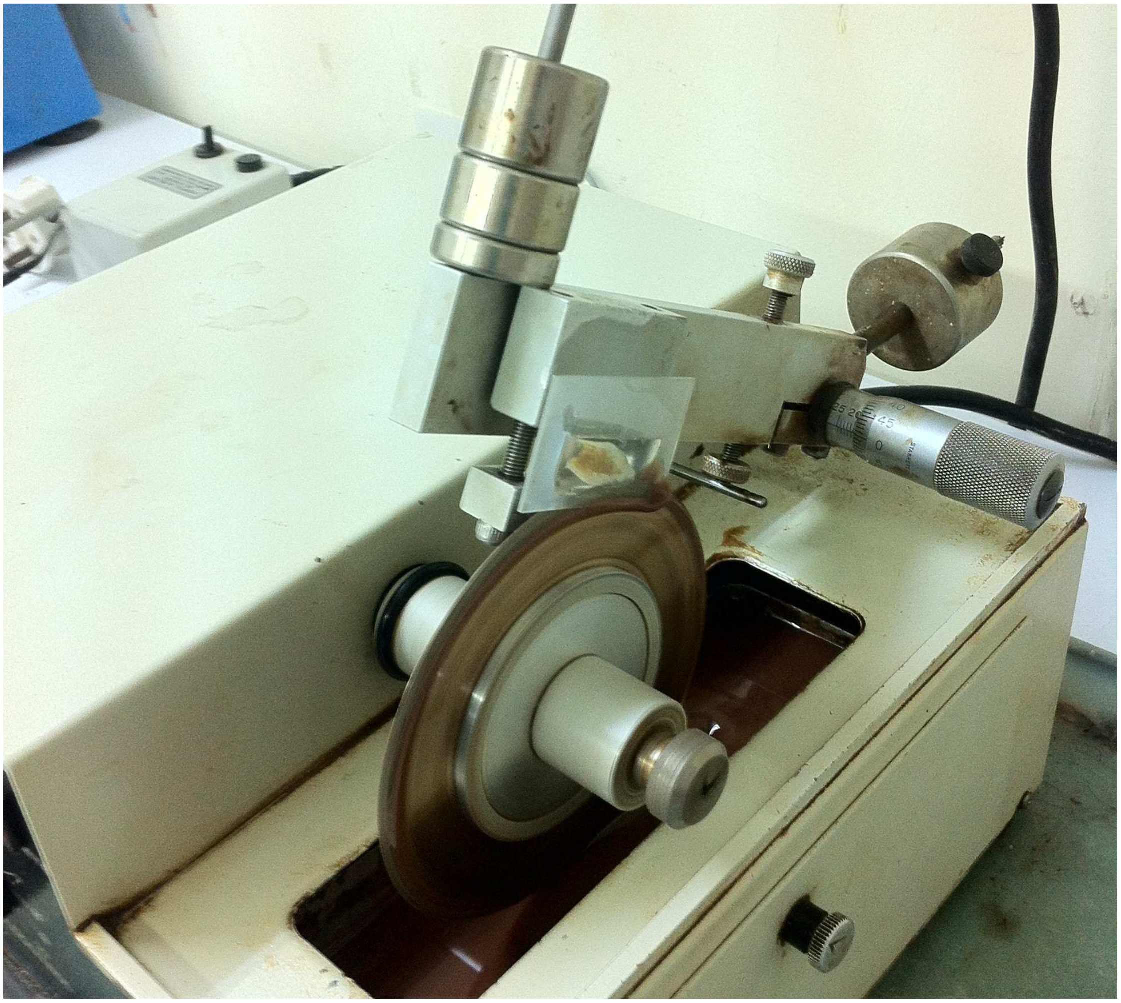


Figure 4.4: Slow speed saw making second cut through embedded tooth with attached glass slide. (Photograph by Teresa Wilson)

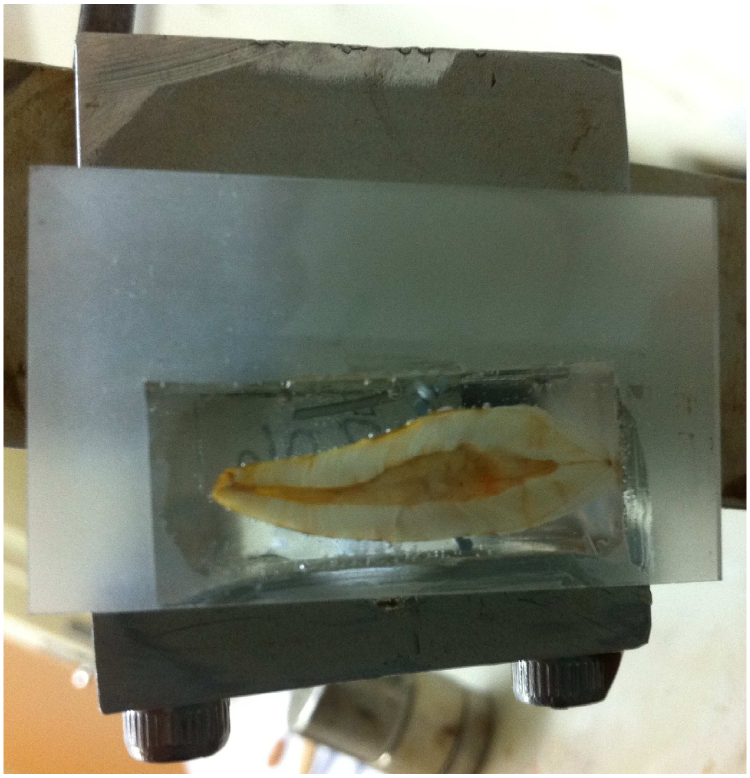


Figure 4.5: Tooth sample after first longitudinal cut with glass slide adhered to the cut surface prior to final cut of the thin section. (Photograph by Teresa Wilson)

4.5 Histological Analysis

Examination of the thin section is done using a Zeiss light microscope that has been set up to project the transmitted light at an angle through the sample (Wilson and Shroff, 1970). This angled light allows for the topography of the striae of Retzius to show as a three dimensional image. The microscope is mounted with a Nikon D70 DSLR camera using a camera/microscope adapter. Micrographs of each tooth will be taken at appropriate magnifications to see the necessary enamel features (See Figure 4.6).

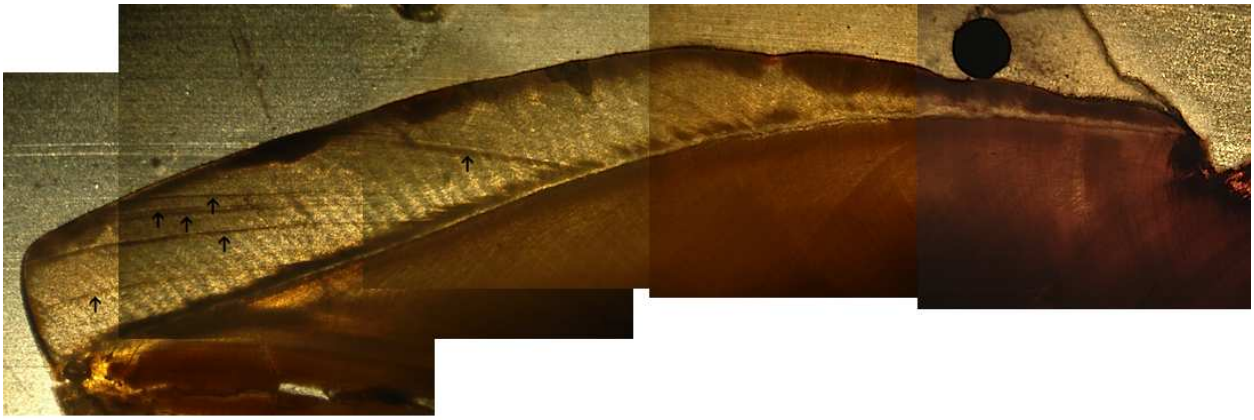


Figure 4.6: Micrograph montage (x5 magnification) of thin sectioned Tooth 11256 showing dentin, enamel (labial side), and Wilson bands (arrows). (Photograph by Teresa Wilson)

4.5.1 Defect Recording Procedure

Identification of LEH defects will be accomplished through macroscopic measurement and microscopic analysis of the thin-sectioned teeth. Differences in LEH measurement between macroscopic and microscopic analysis have been shown in previous studies (Hassett, 2012; Martin et al., 2008). Comparing the measurement data collected from these methods will allow for an evaluation of these methods. It has been suggested by researchers that a comparison of the widely used macroscopic method and a histological method would help to provide better measurements of LEH location. The microscopic examination will also provide a way to identify and eliminate false hypoplasias from the study.

Micrographs of LEHs and Wilson bands of the thin-sectioned teeth were analyzed and measurements of the defects were made in an image measurement software program (KLONK Image Measurement). In order to be able to measure the full length of the crown, the micrographs of each tooth to create a montage of the entire enamel surface in one image in an image editing program (see Figure 4.6). Some of the teeth exhibit low to moderate attrition to the cusp. In order to get a measurement of the complete tooth crown height, the curvature of the crown was extended forward to approximate the length of the tooth (see Figures 4.7 and 4.8).

4.5.2 Age of Enamel Defects

Age at stress event resulting in a hypoplasia will be determined using the method developed by Reid and Dean (2000). This method uses the percentile of tooth that had developed at the time of the event to assign an estimated age. The first method for estimating the age at which a defect was acquired is based on the research of Swärdstedt (1966) and Goodman et al. (1980) that divided the crown into sections based on six-month development increments called the "chart method". Goodman and Rose (1990) refined this method using regression equations to find a precise age versus an age range that the chart method provides. Recognizing that these developmental increments were not accurate because there is a different rate of development in the cuspal enamel than in the rest of the crown, Reid and Dean (2006) conducted a histological study to examine the developmental features in detail and to improve estimates for the age of development at various locations of the crown. Figure 2 shows a decile chart with the age estimates for each location based on the chart method, regression equations, and the Reid and Dean study. The largest differences in these three methods are seen in the cuspal enamel with the chart method and regression equations underestimating the age. In order to get an accurate picture of what is happening in those early years (~0.5-2.5 years), it is important to take into account the differences in enamel formation times.

As Reid and Dean (2006) have shown, the time of enamel formation can vary between populations. Several studies have suggested that more study needs to done on the differences in tooth development among different populations to form a better method (Martin et al., 2008; Reid and Dean, 2000; Ritzman et al., 2008). This study will develop an enamel

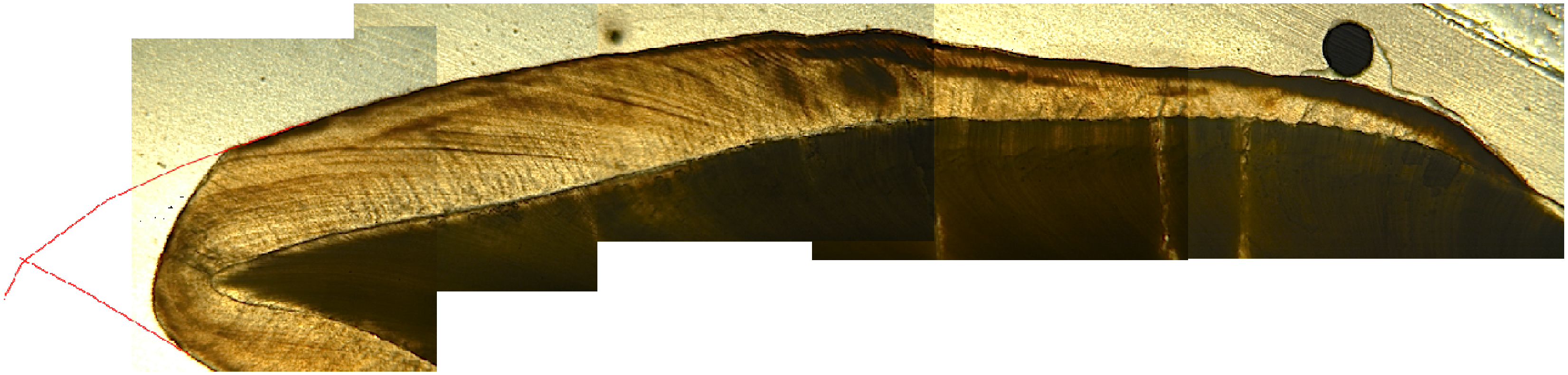


Figure 4.7: A montage of Tooth 11654 showing the extension of the cusp area affected by attrition to approximate the crown height.

Figure 4.8: A montage of Tooth 11045 showing the extension of the cusp area affected by attrition to approximate the crown height.

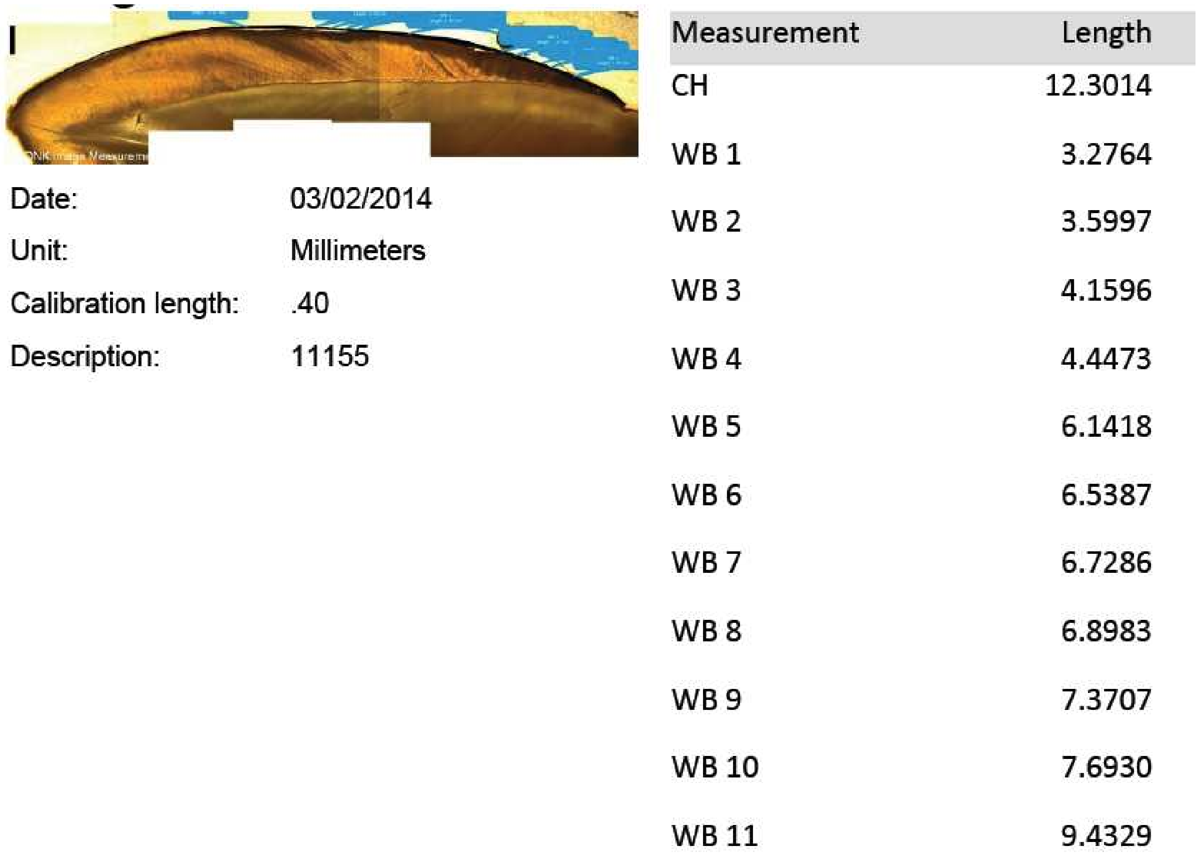
development index that is specific to Northern Jordan using the method outlined in Antoine et al. (2009) by examining the circadian periodicity of the cross-striations within the enamel. This geographically specific index can then be compared with the existing indices from a modern population (Reid and Dean, 2000) as well as two archaeological populations from Europe and South Africa (Reid and Dean, 2006).

In order to find the percentile where the defect resides, it is necessary to determine the crown height (CH) of the tooth and the measurement of the defect. LEH measurement (LEHM) is the distance from the occlusal wall of the LEH to the cementoenamel junction (CEJ). The occlusal wall of the defect is used for measuring because this is where the ameloblasts show the first effects of the stress event (Hillson and Bond, 1997). In the case of teeth with wear to the cusp, an estimation of the full crown height can be used. Dividing the LEHM by the full CH will provide the percentile of the defect:

$$\frac{LEHM}{CH} x100 = Percentile \tag{1}$$

Wilson bands are identified using the microscope techniques described above (C5a.). An accentuated striae of Retzius is only considered a Wilson band if it spans at least 75% of the distance between the crown surface and the DEJ (FitzGerald and Saunders, 2005; Goodman and Rose, 1990). Goodman and Rose (1990) suggest a method of determining the age at which a Wilson band formed by assuming that the enamel will develop along the dentinoenamel junction (DEJ) at a constant rate. For this method Wilson bands are measured from the CEJ to the point where the defects encounter the DEJ. The DEJ is divided into equal sections based on the known time of development for that tooth type. Thus the location of the defect along the DEJ will indicate the age at which the defect was created. Alternatively, the Wilson band can be measured at the enamel surface to the CEJ and the age can be determined using the LEH method. A comparison of these two methods can give a better indication of how accurate these measurements are to determining the same age.

For this study, the LEH defects and Wilson bands were measured from the CEJ to the to the start of the defect along the outer surface of the enamel. This will reduce the amount of error involved in the statistical analyses that compare the LEHs and Wilson bands. The imaging software used for this study provides the capability of making multiple measurements on one image. These measurements are then collected into a spreadsheet for later analysis (see Figure 4.9).



Date: 03/02/2014
Unit: Millimeters
Calibration length: .40
Description: 11155

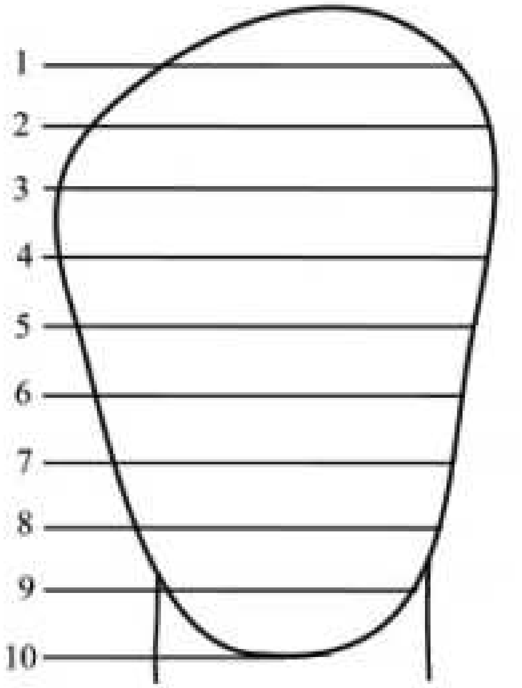
Measurement	Length
CH	12.3014
WB 1	3.2764
WB 2	3.5997
WB 3	4.1596
WB 4	4.4473
WB 5	6.1418
WB 6	6.5387
WB 7	6.7286
WB 8	6.8983
WB 9	7.3707
WB 10	7.6930
WB 11	9.4329

Figure 4.9: Measurements from Tooth 11155 showing crown height (CH) and the measurements for 11 Wilson bands from the KLONK Image Measurement program.

The measurement data was collected for all teeth in the sample whether or not they exhibited any LEHs or Wilson bands. These negative results were indicated in the measurement data spreadsheet so that the tooth could still be included in the sample. The absence of enamel defects is an important piece of information that is lost if teeth without defects are excluded from the results.

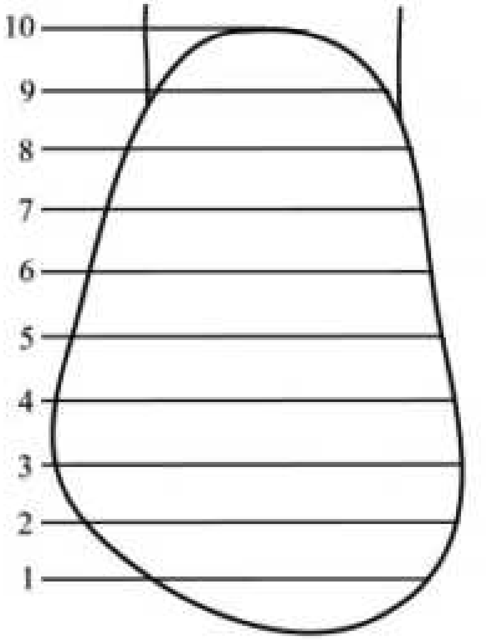
After the data was collected, the raw measurement scores were converting using the percentile formula. Once the percentile location was determined, the defect was placed into the proper decile to estimate the age at which the defect occurred. The decile system used in this study is the Reid-Dean Method (Reid and Dean, 2006) that differs in several ways from the Chart Method commonly used in bioarchaeological studies (Buikstra and Ubelaker, 1994) and the estimated age ranges based on regression equations. Figures 4.10 and 4.11 show a diagram of how the mandibular canine and maxillary canine are divided into equal decile proportions. The figures also show a comparison between the Chart Method, Regression Equations, and the Reid-Dean method. The largest differences in age estimatation amoung the methods occur at the at the cusp, where the Reid-Dean method gives higher age estimates. The higher deciles (older ages of formation) become more consistent across all methods.

Figure 4.10: Decile chart for mandibular canine showing the age estimates for the chart method, regression equations, and the Reid-Dean method. (Adapted from Reid and Dean 2006; Ritzman et al. 2008)



Decile	Chart Method	Regression Equations	Reid-Dean Method
1	0.5-1.0	0.68	1.6-1.7
2	1.0-1.5	1.33	1.9-2.0
3	1.5-2.0	1.98	2.1-2.3
4	2.0-2.5	2.62	2.4-2.7
5	2.5-3.0	3.27	2.3-3.1
6	3.0-3.5	3.92	3.2-3.6
7	4.0-5.0	4.56	3.7-4.2
8	4.5-5.0	5.21	4.2-4.9
9	5.5-6.0	5.85	4.7-5.6
10	> 6.5	6.5	5.2-6.2

Figure 4.11: Decile chart for maxillary canine showing the age estimates for the chart method, regression equations, and the Reid-Dean method. (Adapted from Reid and Dean 2006; Ritzman et al. 2008)



Decile	Chart Method	Regression Equations	Reid-Dean Method
1	0.5-1.0	0.68	1.7
2	1.0-1.5	1.33	1.9
3	1.5-2.0	1.98	2.1-2.2
4	2.0-2.5	2.62	2.3-2.4
5	2.5-3.0	3.27	2.5-2.7
6	3.0-3.5	3.92	3.8-3.0
7	4.0-5.0	4.56	3.5-3.8
8	4.5-5.0	5.21	4.0-4.3
9	5.5-6.0	5.85	4.4-4.8
10	> 6.5	6.5	4.8-5.3

For this study, I selected ten age ranges that best encompassed estimates for both the mandibular and maxillary canines so all of the teeth could be combined into one sample. The ten age ranges include: (1) 1.5-1.7 years, (2) 1.7-2.0 years, (3) 1.9-2.3 years, (4) 2.2-2.7 years, (5) 2.7-3.1 years, (6) 3.0-3.6 years, (7) 3.4-4.2 years, (8) 4.2-4.9 years, (9) 4.8-5.6 years, and (10) 5.6-6.2 years. Some of the age ranges have an overlap of about 0.1 year due to the way that the deciles are estimated in the Reid-Dean Method. This overlap will not have a significant effect on the analyses because it is a short period of time and the age ranges are only representative of estimates. In order to place the defects into these ten age ranges, it was necessary to combine deciles in the Reid-Dean Method into the chosen decile ranges in this site for the mandibular canines.

4.6 Tomb Dating

Accurate dating of the tombs is important to establishing the correct trends in time periods. Many of the tombs and skeletons have been dated using grave goods (scarabs, lamps, glass, etc.) and this information can be found in the site reports and site manuscripts (Al-Muheisen, 1992, 1989; El-Najjar, 2011; Rose and Burke, 2004 a).

In some cases the tomb type can give a good indication of the time period in which the individual or individuals was buried (Waterhouse, 1998), however the sites of this study have a long history of tomb reuse meaning that the person in the tomb may be from a later time period than the tomb architecture would indicate. Recent radiocarbon dating of the skeletons from Natfieh (Al-Bashaireh et al., 2011) and Tell al-Husn (Al-Muheisen and Al-Bashaireh, 2012) give a comparative sample in which to look at unknown tombs. By comparing the funerary objects and general architecture of the tombs, it is possible to get a better indication of the timing of certain unknown individuals. Al-Bataineh et al. (2011 b) used a modified tomb typology system at Ya'amun that better describes and separates the tombs at these rural sites.

Al-Shorman (2004 a) used GIS to map the spatial relationship of three cemeteries at Yasileh and demonstrated that there is a clear pattern in location and orientation based on time period. This variance in tomb location and orientation is based on differences in religious practice and can possibly be used to identify the date of some tombs. There is also a noticeable absence of Iron Age samples from the sites with longer occupation times like Sa'ad and Ya'amun. Excavations have revealed Iron Age buildings and pottery at Ya'amun, which suggests continuous occupation through this time period. However, the tombs identified as possibly belonging to the Iron Age are empty. There is also a noticeable absence of Iron Age burials from all over the highlands in the Levant and several theories have been developed to explain this including the use of jar burials instead of stone cut tombs (Ji, 1995), abandonment of all burial customs in favor of leaving remains on the surface (Faust, 2004; Kletter, 2013), and possible consecutive reuse of tombs from the Bronze Age to the Iron Age and again in the Roman/Byzantine periods (Al-Shorman, 2007). A closer examination of certain clusters of tombs at Ya'amun may yield these missing Iron Age burials.

4.7 Summary

The methods outlined in this study were developed to find solutions to the principle questions of health and nutrition for the populations of this study. Histological analysis allows for a deeper look into the stress experiences of these people. Samples were selected to maximize the effectiveness of the data and statistical analyses. Bioarchaeology is often contrained by the amount of data that can be collected. Ideally researchers want to have large numbers of samples to test because large samples show better correlations and trends by negating outliers.

Bioarchaeologists are limited by the number of skeletons excavated from a particular site as well as the preservation of those skeletons. This study was only able to include a small number of teeth from the site of Natfieh due to poor preservation of the skeletons.

When performing any histological and microscopic analysis, it is important to first give the samples a macroscopic examination. In this study, I chose to do multiple evaluations of the conditions of each tooth as well as document how the surface of the crown looked through photographs before they were turned into slides. Photographs provide another source of information that can be useful when the histological examination is unclear. The photographs are also now available for any future research even though the teeth themselves are no longer available.

The thin sectioning techniques chosen for this study have been used with only slight differences for many years in various enamel studies (Goodman and Rose, 1990; Marks et al., 1996; Rose et al., 1978). However the methods for estimating the age at which defects were formed has gone through several modifications as discussed in this chapter. Research on these methods will continue because none of the current methods are complete. It may be that each population will have a time and place specific set of standards for aging enamel defects.

Chapter 5 - Results and Discussion

5.1 Introduction

This chapter presents the results of the analyses of this study and provides a discussion of the relevance of the results to the research hypotheses. This section has been divided into sections so that each hypothesis is addressed separately. A summary of the results from the tested hypotheses will be given in the concluding chapter.

5.2 Life Stages and Disease

In order to see differences or changes in childhood stress related to life stages and disease it is important to look at the amount and frequency of enamel defects by age group. Each tooth was divided into ten equal parts that demonstrate growth at ten different age ranges. A look at the number of enamel defects in each age grouping can indicate if the children of these sites were experiencing increased physiological stress at certain life stages. Disease experiences are more difficult to see in the enamel defect record, however unexpected increases in may be indicative of susceptibility to certain childhood diseases at specific ages.

5.2.1 Enamel Defects by Age

A calculation of the average number of defects in the whole sample by combining all time periods and sites shows a clear difference between the ages at which LEHs and Wilson bands are most prevalent. Figure 5.1 shows the average number of enamel defects for each age group. The average number of LEHs as shown by the solid black line shows a peak of defects in the 4th decile (2.2-2.7 years). The average number of Wilson bands as indicated by dashed bars shows a peak in defects at the 5th decile (2.7-3.1 years). Figure 5.1 shows that there is a higher mean number of Wilson bands as compared to LEH defects.

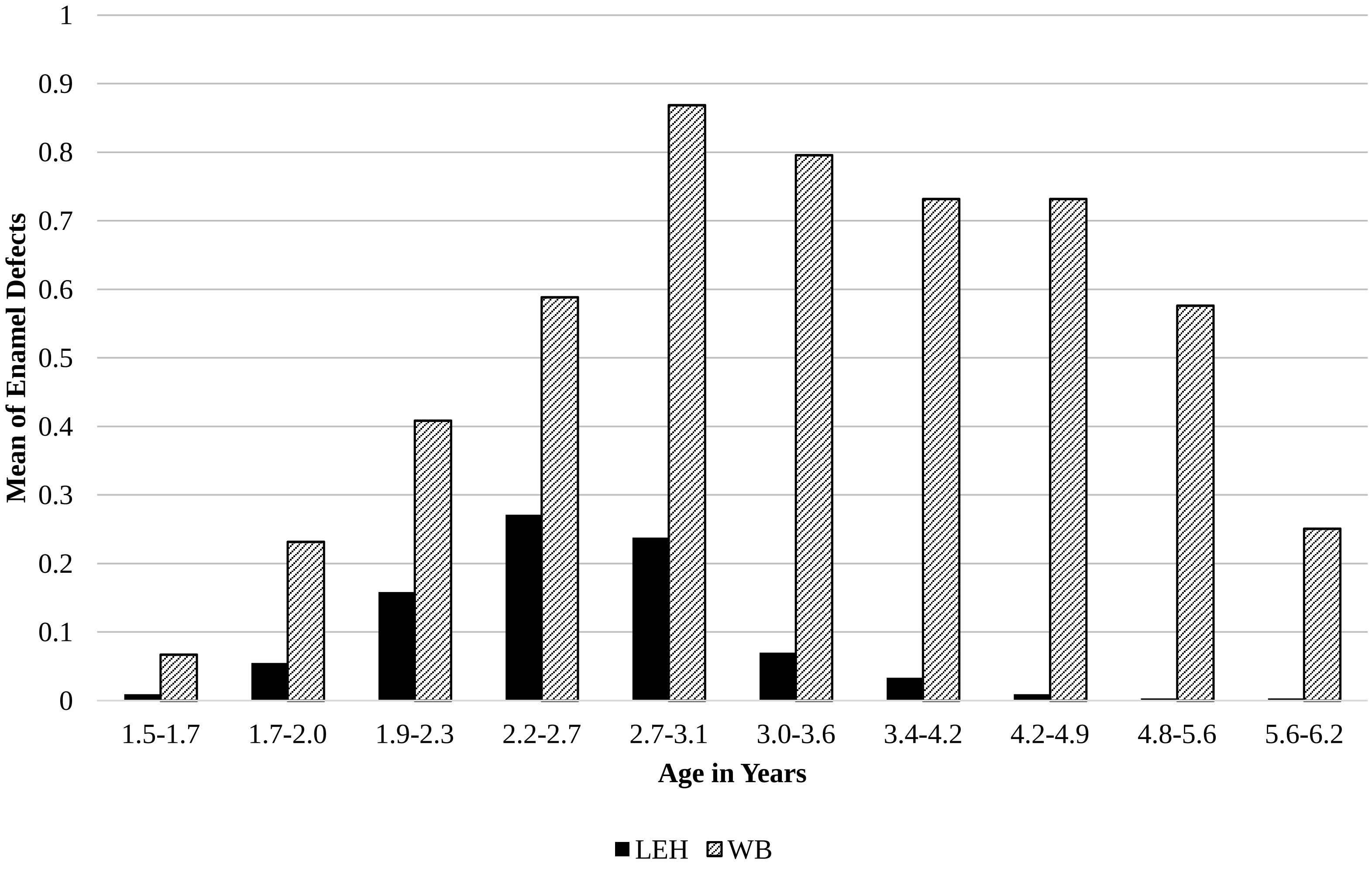


Figure 5.1: Average number of enamel defects by age groups across all sites and time periods.

The mean number of LEHs never reaches the same number of Wilson bands for any given age range. Figure 5.1 shows that LEHs rise to reach their peak and descend to almost zero in only seven deciles. Conversely, the mean number of Wilson bands demonstrates a perceptible bar on the graph throughout the ten deciles. The average number of Wilson bands rose steadily through the first five age groups before a small decline and plateau between 3.0 to 4.9 years. The last two age ranges show a quick decrease to about an average of 0.25 Wilson bands in the last decile.

5.2.2 Discussion

Without taking into account the effects of site location and time period, the analysis of the average number of enamel defects through the chosen age ranges shows a disconnect between the ages at which children are susceptible to LEHs and Wilson bands. With an understanding that the combinations of conditions and physiological stressors necessary to produce each type of enamel defect, it is apparent that the people of this study were experiencing different kinds and degrees of stress at different stages of their childhoods.

LEHs are formed when there is a combination of extreme nutritional and systemic stress. The majority of LEHs seen in this sample are between 1.7 and 4.2 years. This age range is consistent with the initiation and completion of weaning activities. As the child grows larger, the necessary caloric intake increases with increased weight. There comes a time when breast milk is not longer adequate to provide the minimum number of calories for a child to thrive. The average age of completion of weaning of non-industrialized populations is around 3 years of age (Sellen, 2006). The peak average numbers of LEHs occurs between 2.2 and 2.7 years, which is during the expected age range in which weaning would be commenced, but before the age of weaning completion. Upon completion of weaning, the child will be completely dependent on food sources other than breast milk and will have the ability to obtain the necessary calories from solid foods. It is expected that after weaning is completed, a child will start to become accustomed to their new diet and the number of nutrition related enamel defects will decrease as long as they have access to adequate amounts of food. Figure 5.1 shows that the populations of this study were no longer experiencing severe nutritional deficiencies after around 4 years of age.

The average number of Wilson bands peaks around the time that weaning is entering completion. However unlike LEH averages, the Wilson band averages persist at high rates until around 5.6 years. The conditions necessary for the formation of Wilson bands are not as severe as those necessary for LEH formation. Wilson bands can be found during periods of minor physiological stress and represent a record of subtle changes in health. It is expected that the average number of Wilson bands would also increase during the weaning process, however the continuation of high numbers of Wilson bands past the completion of weaning may be indicative of continued nutritional stress. Although the children may have been obtaining enough calories so that ameloblasts could lay enamel the whole length of the crown and not form LEHs, the Wilson bands indicate that the children were still experiencing a less severe form of stress. The high average of Wilson bands between 2.7 and 5.6 years may indicate an increased susceptibility to childhood diseases. Bouts of diarrhea and dehydration during these early years could account for these higher averages. As the children became more accustomed to their diets and their immune systems developed, it is expected that early childhood illnesses would decrease. The large drop in the average number of Wilson bands after 5.6 years indicates that the children were no longer experiencing these subtle stress events.

5.3 Climate Change

As with any study that looks at climate change, it can be a challenge to find ways to see the effects that the changing climate may have on a population. With current methods and based on the scope of this research, it is impossible to determine the effects that small climatic events may have had on the populations in this study. Due to the absence of burial records or another way to determine the exact time in which the individuals lived, it is only possible to know the general time periods in which they lived. Some of these time periods span hundreds of years and precise climate data will not be useful for this study. That being said, the region does have a rich history of climate research that can help to establish larger and more broadly applicable shifts in the climate. Evidence for differential climate may be seen in the analysis of enamel defects between the Bronze Age and the Byzantine era because there is a documented shift from a warmer and drier average climate during the Bronze Age to a wetter and cooler average climate during the Byzantine era.

5.3.1 Enamel Defects by Climate Events

Examining the mean number of enamel defects per individual by time period shows varied trends between LEHs and Wilson bands. Figure 5.2 shows an overall lower average of LEH defects as compared to Wilson band averages across the time periods. This graph shows minor fluctuations in the average number of LEH defects with the highest averages of about 1 LEH defect per person occurring during the Middle to Late Bronze Age and the Late Roman to Early Byzantine. However the average of LEHs per person is the lowest in the Byzantine with the average being about 0.67 defects per person. The p-value ($p < 0.1676$) for the ANOVA analysis for LEHs for these four time periods shown in Table 5.1 does not indicate a significant difference in the numbers of LEHs from the Bronze Age to the Byzantine. This demonstrates that there is no perceptible difference between the likelihood of having a stress event severe enough to cause a LEH in the Bronze Age as compared to the Byzantine era.

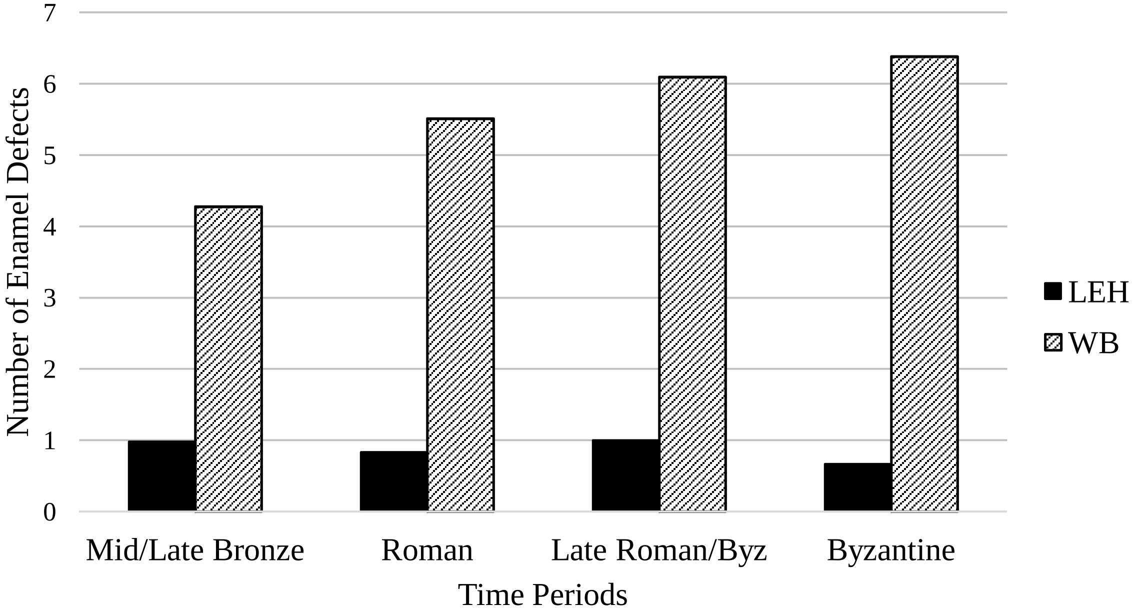


Figure 5.2: The mean of enamel defects per person by time period.

Table 5.1: ANOVA test results for LEH totals for all time periods.

Source	**DF**	**Sum of Squares**	**Mean Squares**	***F* value**	***P* value**
Model	3	4.46680	1.48893	1.6966	< 0.1676
Error	320	280.82641	0.87758		
C. Total	323	285.29321			

Figure 5.2 shows a graphical representation of the average number of Wilson bands per person in the four time periods. The Middle to Late Bronze Age has an average of 4.27 Wilson bands per individual and the Byzantine has an average of 6.38 Wilson bands per individual.

Figure 5.2 demonstrates the gradual increase in the average number of Wilson bands per individual from the Bronze Age to the Byzantine. The ANOVA analysis for the numbers of Wilson bands from Table 5.2 shows a p-value ($p < 0.0015$) that demonstrates a significant difference in the Wilson bands between the time periods. The analysis of variance shows a higher likelihood of have a Wilson band producing stress event in the Byzantine than in the Bronze Age for the study sites.

Table 5.2: ANOVA test results for Wilson band totals for all time periods.

Source	**DF**	**Sum of Squares**	**Mean Squares**	***F* value**	***P* value**
Model	3	210.7413	70.2471	5.2315	< 0.0015
Error	320	4296.8976	13.4278		
C. Total	323	4507.6389			

Climate differences were the greatest between the Bronze Age and the Byzantine. The results of a *t*-test (Table 5.3) show significant differences between these two groups. By removing the other two time periods from the analysis, it is confirmed that there is a significant effect for time period on average LEH formation, $t(137) = -2.18$, $p < 0.01$, with the Bronze Age samples showing higher numbers of LEHs as compared to the Byzantine Period. There is also a significant effect for time period on Wilson band formation, $t(88) = 3.01$, $p < 0.001$, with the Byzantine Period showing a higher likelihood of individuals having more Wilson bands than in the Bronze Age.

Table 5.3: *t*-test results comparing the numbers of enamel defects in the Middle to Late Bronze Age and the Byzantine Period.

	Time Periods			
	Mid-Late Bronze Age	**Byzantine**	***t***	***df***
LEHs	0.98 (1.00)	0.67 (0.86)	-2.18*	137.08
Wilson bands	4.28 (3.30)	6.38 (4.88)	3.01***	87.68

Note. * = $p < 0.01$, *** = $p < 0.001$. Standard deviations appear in parentheses below the means.

5.3.2 Discussion

As discussed in Chapter 3, the average climate for the region of study had a shift from a drier annual rainfall during the Bronze Age to a progressively higher rainfall during the Byzantine. Because it has been shown that the populations were eating the same types of food, it is expected that the wetter periods would result in higher crop yields as opposed to the drier periods. If the drier climate of the Bronze Age had a negative impact on nutrition related stress, this research anticipated seeing higher instances of LEHs and Wilson bands during the Bronze Age and fewer enamel defects during the wetter Roman and Byzantine Periods. However, the analysis shows a difference between which individuals from certain time periods, with those people in the Roman and Byzantine subsamples having a higher likelihood of forming LEHs and Wilson bands.

When only considering the analysis of variance across all time periods, the average number of LEHs per person across all time periods is not significantly different suggesting there is no evidence for differences in severe nutritional deficiencies across the time periods. However, the *t*-test results show that only reflect a comparison between the Bronze Age and the

Byzantine show a significantly higher likelihood of individuals from the Bronze Age having more LEHs than in the Byzantine. When both analyses are considered it is likely that although the *t*-test shows a significant difference between the two time periods, the fluctuations occurring through all of the time periods give a better indication of what is occurring. This suggests that the severe nutritional deficiencies necessary for the formation of LEHs were not affected by the shift in climatic conditions.

The average number of Wilson bands increases with the later periods. This does not support the assumption that improved health will be seen in periods with higher annual rainfall as is seen in the climate data. The absence of difference in LEHs and the increase in Wilson bands indicates that the climate did not have a direct effect on the processes that created the enamel defects. Although this analysis shows that the differences in climate between the Bronze Age and the Byzantine did not have an impact on the nutritional needs of the children, it demonstrates that there is something that has changed between these time periods that has a negative effect on the physiological stress of the children in the later time periods.

5.4 Social and Political Change

As demonstrated in the discussion on the effects of climate change on the nutrition of the populations, there is something other than a climate shift from a lower annual rainfall to a higher annual rainfall that is affecting the amount of physiological stress seen in the enamel of the study sample. The time periods selected for this study are based on the social and political divisions that mark this region of the Levant during the scope of this study. The Bronze Age encompasses the longest period of time and is marked by influences from Egypt as is seen in the scarabs collected from the tombs. The Iron Age and Hellenistic period are most likely missing from the sample for cultural and political reasons. The influences of the Roman Empire in the part of the

Levant are evident in the architecture, art, and tomb construction. The shift to the Byzantine Empire brought a new religion and attitudes about life and death. Although climate could not account for the differences seen in the enamel defects, it is possible that the shifting political powers could have had an effect on the region that would manifest as physiological stress seen in the dentition.

5.4.1 Enamel Defects by Time Period

The graphical and statistical analyses shown under the climate change section of this chapter demonstrate the major differences between enamel defects across the time periods of this study. Adding to these analyses, a closer look at each time period adds more detail to the overall picture of what is occurring across the large span of time included in this research. Figures 5.3, 5.5, 5.7, and 5.9 show a comparison by site of the mean number of Wilson bands by age group for the four time periods. Figures 5.4, 5.6, 5.7, and 5.10 show a comparison by site of the mean number of LEHs by age group for the four time periods.

Ya’amun is the only site represented in the Middle to Late Bronze Age sample set. The overall distribution of the Wilson bands (Figure 5.3) and LEHs (Figure 5.4) mirror the results seen in the averages for all sites (Figure 5.1) with the Wilson bands showing a higher overall frequency and longer distribution at the later age ranges as compared to the LEHs. The absence of any other site in this sample set makes it impossible to compare how these Bronze Age samples compare to others in the region. It is important to note the limitations of having only one population/site represented in the analysis of the Bronze Age.

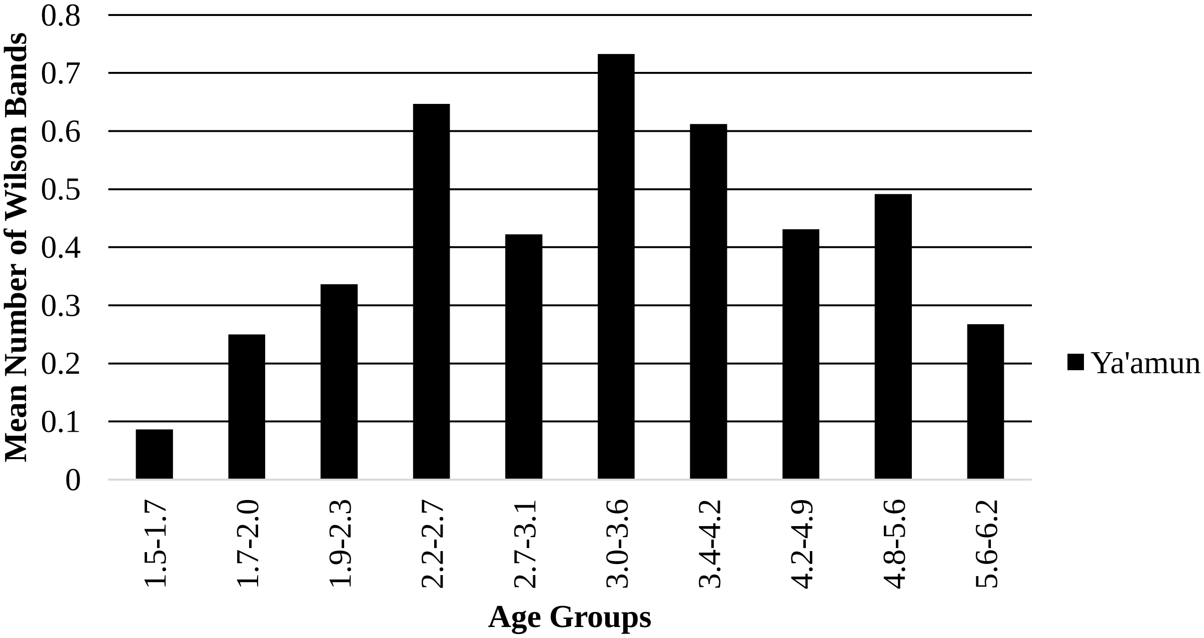


Figure 5.3: The mean number of Wilson bands for the Middle to Late Bronze Age by site and age group.

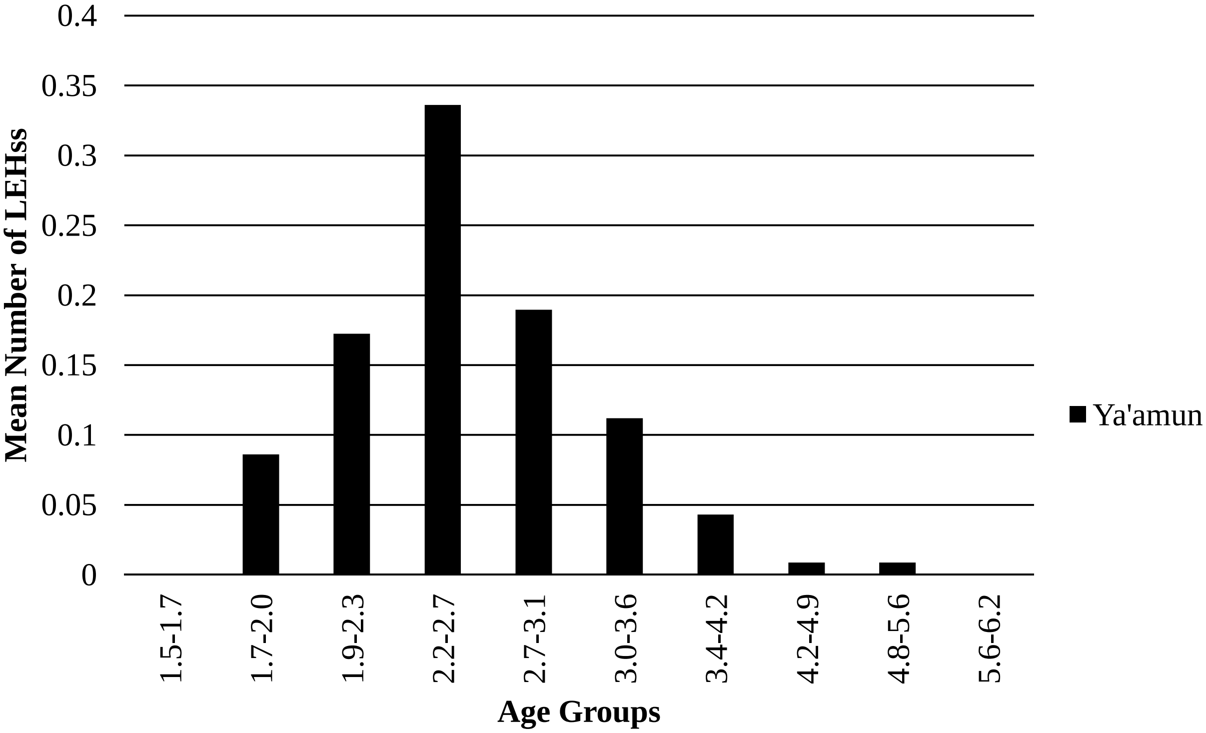


Figure 5.4: The mean number of LEHs for the Middle to Late Bronze Age by site and age group.

The Roman Period is represented by four of the five sites in this study with Natfieh being the only site not present. The distribution of Wilson bands (Figure 5.5) and LEHs (Figure 5.6) both show a peak in frequency at the 2.7-3.1 year age range. However the Wilson bands show a continued higher frequency through the later periods as opposed to the LEHs, which show a steep drop in frequency after the 2.7-3.1 year peak. This is also consistent with the average for all sites and time periods. For LEHs, Ya’amun shows a consistently lower average of defects as compared to the other sites.

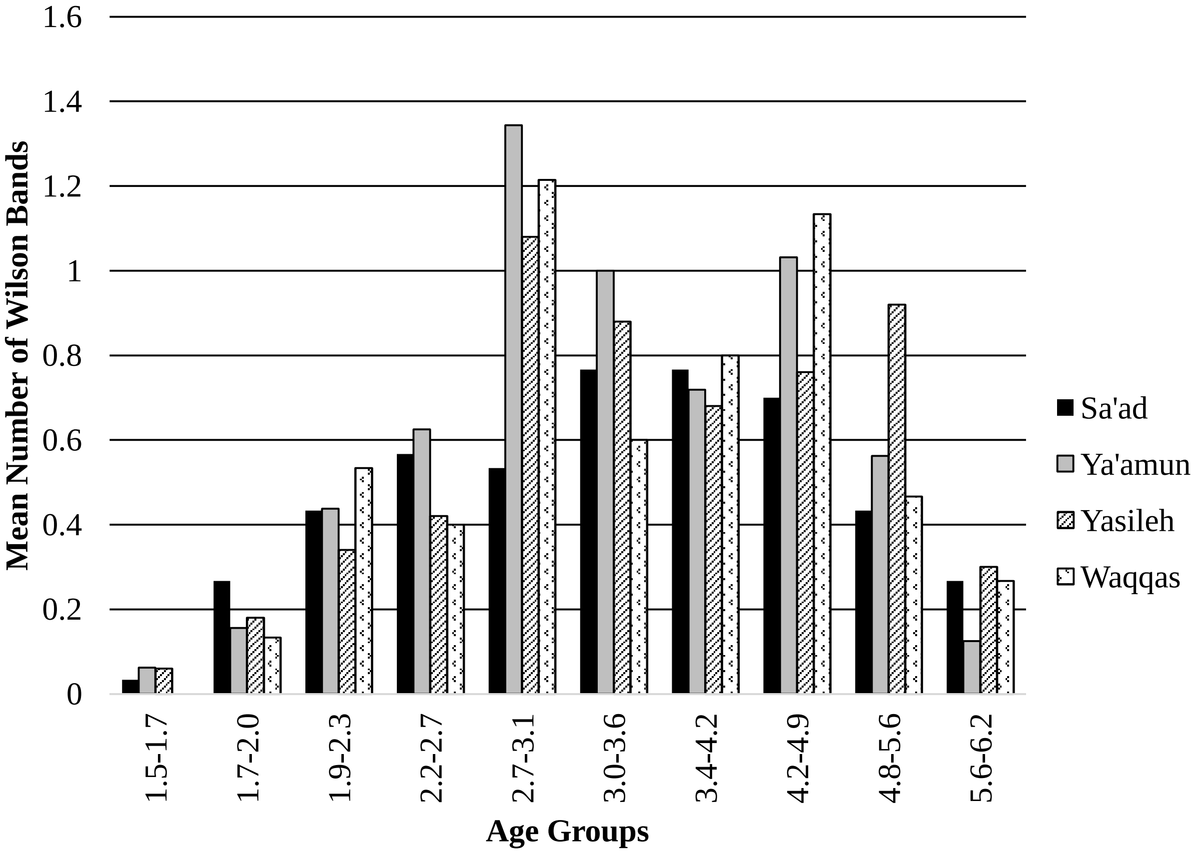


Figure 5.5: The mean number of Wilson bands for the Roman Period by site and age group

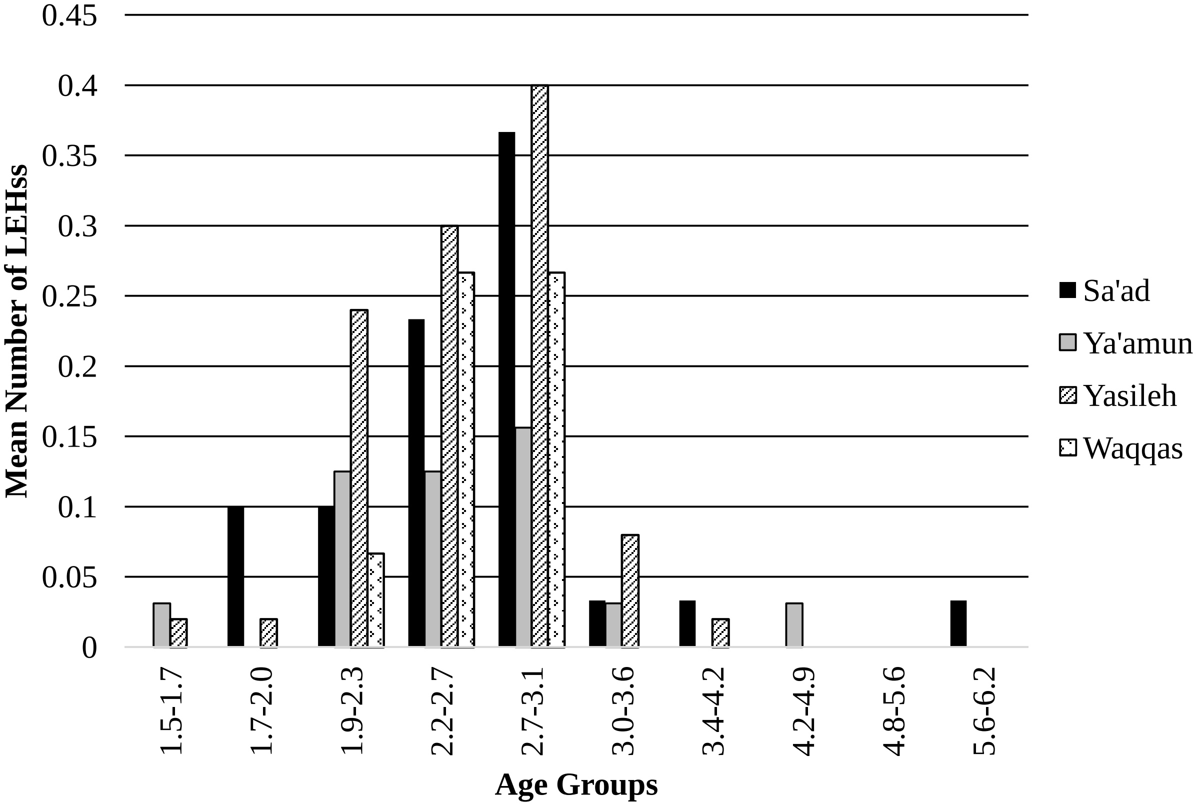


Figure 5.6: The mean number of LEHs for the Roman Period by site and age group.

Sa’ad, Ya’amun, and Natfieh represent the Late Roman to Early Byzantine sample set. The distributions of Wilson bands (Figure 5.7) and LEHs (Figure 5.8) show a longer duration of higher defect frequency in Wilson bands at the later age ranges, while the LEHs peak in the early age ranges and become almost non-existent in the later age ranges. It is important to note that there is only one tooth from Sa’ad included in this time period. The presence of only one sample accounts for the absence of Sa’ad from the LEH graph and the large averages at the 2.2-2.7 year and 4.8-5.6 year age ranges.

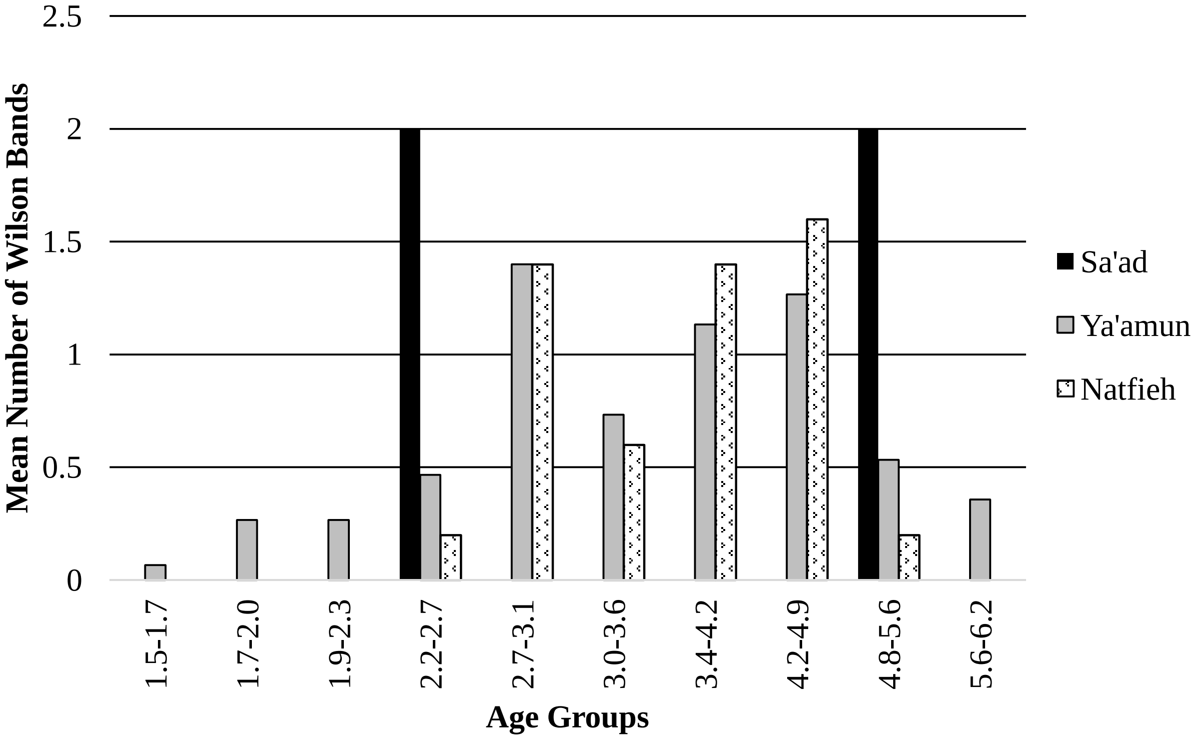


Figure 5.7: The mean number of Wilson bands for the Late Roman/Byzantine Period by site and age group

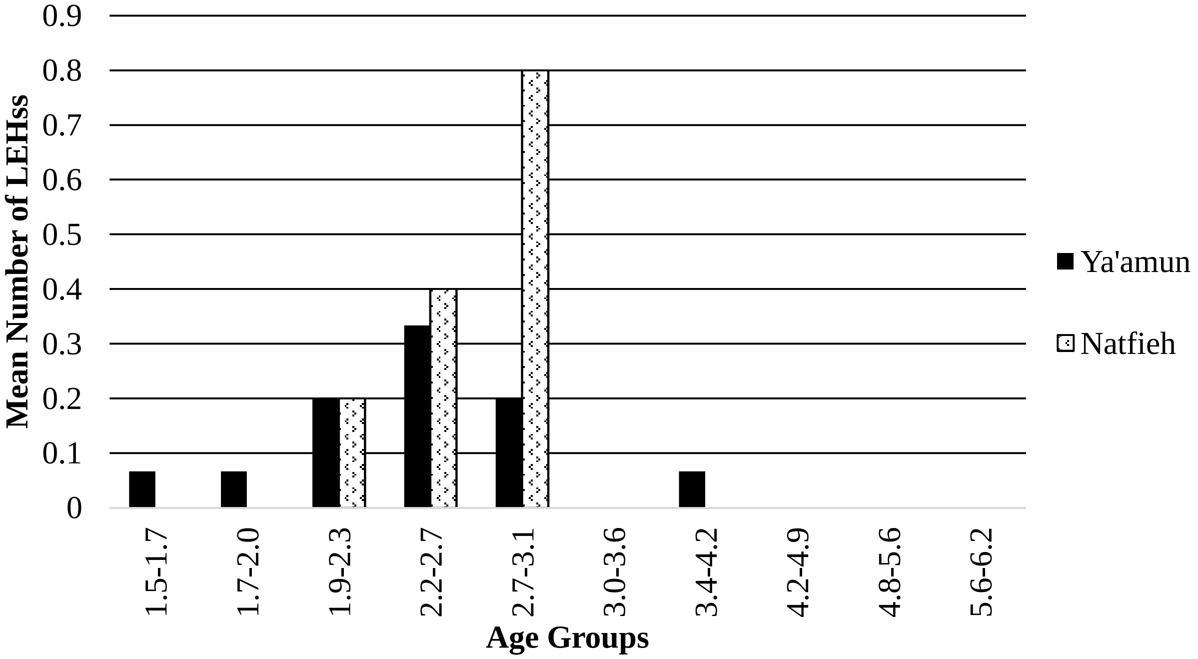


Figure 5.8: The mean number of LEHs for the Late Roman/Byzantine Period by site and age group.

Sa’ad, Ya’amun, and Natfieh are represented in the Byzantine sample set. The overall distribution for the Wilson bands (Figure 5.9) and LEHs (Figure 5.10) mirror the results of the other time periods with a higher frequency of LEHs seen in the early age ranges and a longer period of higher frequency of Wilson bands in the later age ranges. It is again important to note that there is only one tooth from Natfieh included in this time period. The presence of only one sample accounts for the absence of Natfieh from the LEH graph because the tooth did not exhibit a LEH defect. However the average number of Wilson bands for this single tooth falls within the expected range for the 2.7-3.1 year and 3.4-4.2 year age ranges.

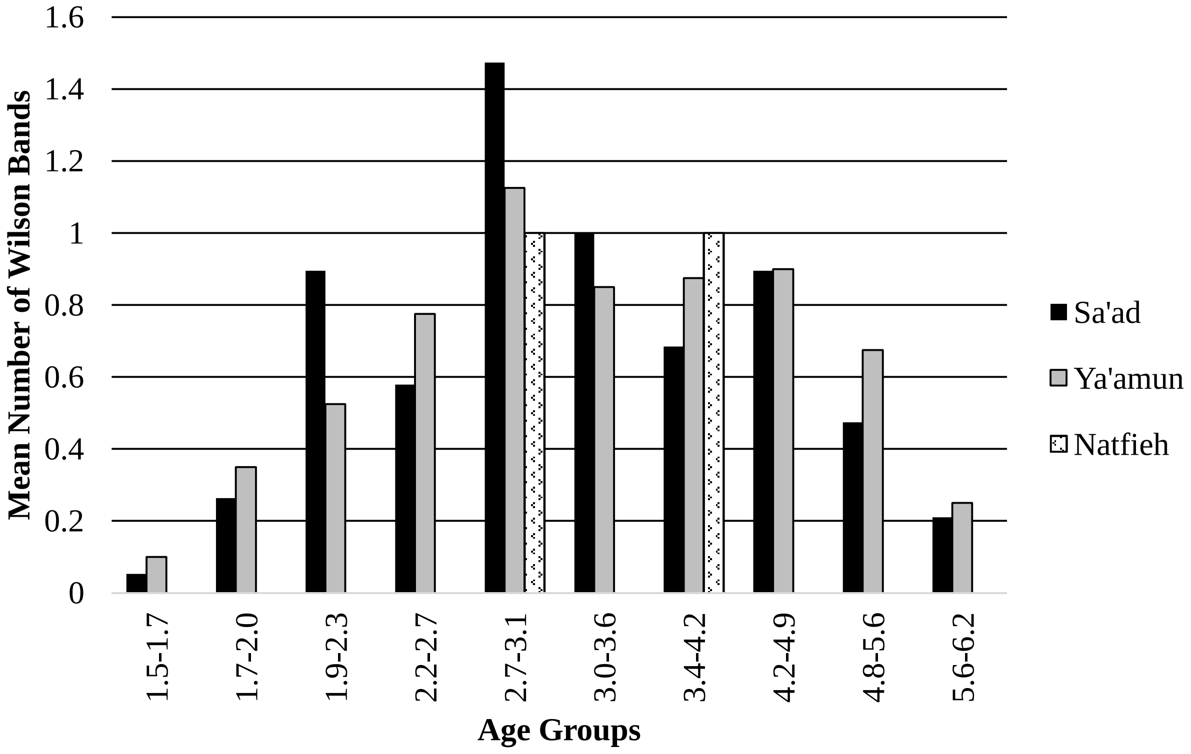


Figure 5.9: The mean number of Wilson bands for the Byzantine Period by site and age group.

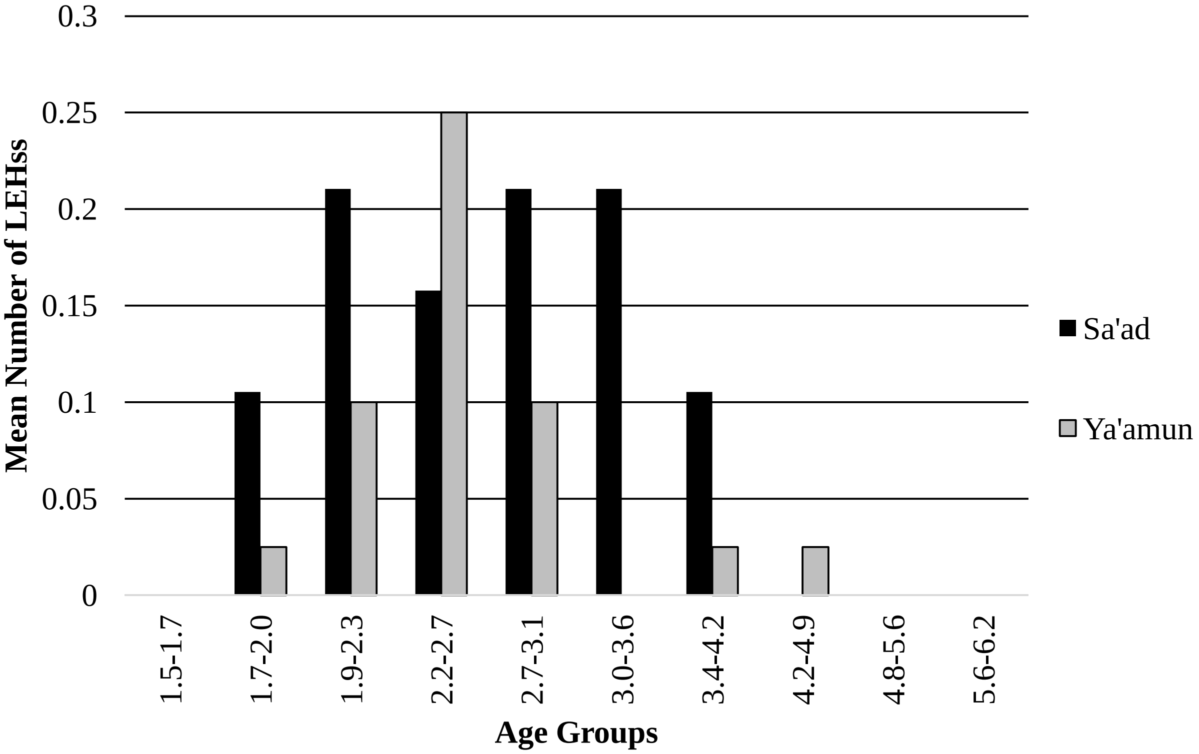


Figure 5.10: The mean number of LEHs for the Byzantine Period by site and age group.

5.4.2 Discussion

The results from the climate change section of this chapter have already demonstrated a difference in LEH and Wilson band frequency based on time periods. This section took a closer look at the how the different sites in the study could have affected this previous analysis. With the exception of two underrepresented sites (Sa'ad in the Late Roman/Byzantine period and Natfieh in the Byzantine period), the distribution for the sites by time period do not show any substantial effects based on site. It was possible that the different locations of each of the sites could have had an impact on the analysis, however this is not seen in the graphs. There is no substantial difference between the trends seen in each time period by site. By removing site location as an unwanted variable to the analysis, it is possible to focus on the effects of the social and political changes on these populations.

As was previously demonstrated (Table 5.2), there is a significant difference in the means of Wilson bands between the four time periods. Climate change was ruled out as a causative factor because an increase in Wilson band frequency was seen with the later time periods as opposed to the expected decrease in frequency if the climate was a contributing variable. Once climate and site location are removed, the remaining variable for this increase in Wilson band frequency is social and political change. The large span of time between in the Bronze Age and the Byzantine allowed for many social changes and these are seen to have an adverse effect on smaller systemic stress events that contributed to the formation of Wilson bands. The analysis of variance on the LEH frequency across the time periods did not show a significant difference, which suggests that the changes to these societies over the time periods did not significantly contribute changes in the severe nutritional deficiencies necessary for LEH formation.

There are several reasons why the shift from the Bronze Age to the Byzantine period shows an overall increase in more subtle stress events. The population density during the Bronze Age was lower than in the later periods. As more people live closer together there is decreased sanitation and a higher likelihood of spreading disease. Attitudes toward children and childhood may have shifted in this region with the changing political structures. If children were given a less than adequate diet, a higher frequency of Wilson bands may be seen. However, there was not an extreme nutritional deficiency because of the number of LEHs did not significantly change in the later periods. Overall access to diet may also have been affected by changing political structures as these rural agriculturalists were producing crops for the larger cities of the region.

5.5 Quality of Life

Overall quality of life of the people of this study is best demonstrated by a collective look at all of the analyses conducted for the previous hypotheses. By looking at the differences in enamel defect frequencies in age groups, by time period, and by site, we can gain a better understand of how these populations lived over the various times and locations. Although the issue of site-specific differences was addressed in the social and political change section of this chapter, this section will look at the average number of enamel defects by site without considering age groups. If a difference can be detected between sites, it would suggest that certain sites had an overall better quality of life as compared to the other sites in this study. However if there is not a discernible difference then the quality of life was consistent across the sites.

5.5.1 Enamel Defects by Site

The means of enamel defects for each site is represented in Figure 5.11 and shows an overall higher frequency of Wilson bands over LEH defects. Graphically the sites appear to be consistent with little variation between sites for either kind of enamel defect. An analysis of variance on the LEHs between the different sites (Table D) does not show a significant difference in LEH frequency ($p < 0.2658$). An analysis of the variance of the Wilson bands (Table E) also does not show a significant difference in Wilson band frequency ($p < 0.9287$). These results suggest there is no statistical difference in the frequencies of enamel defects in the populations of the five sites.

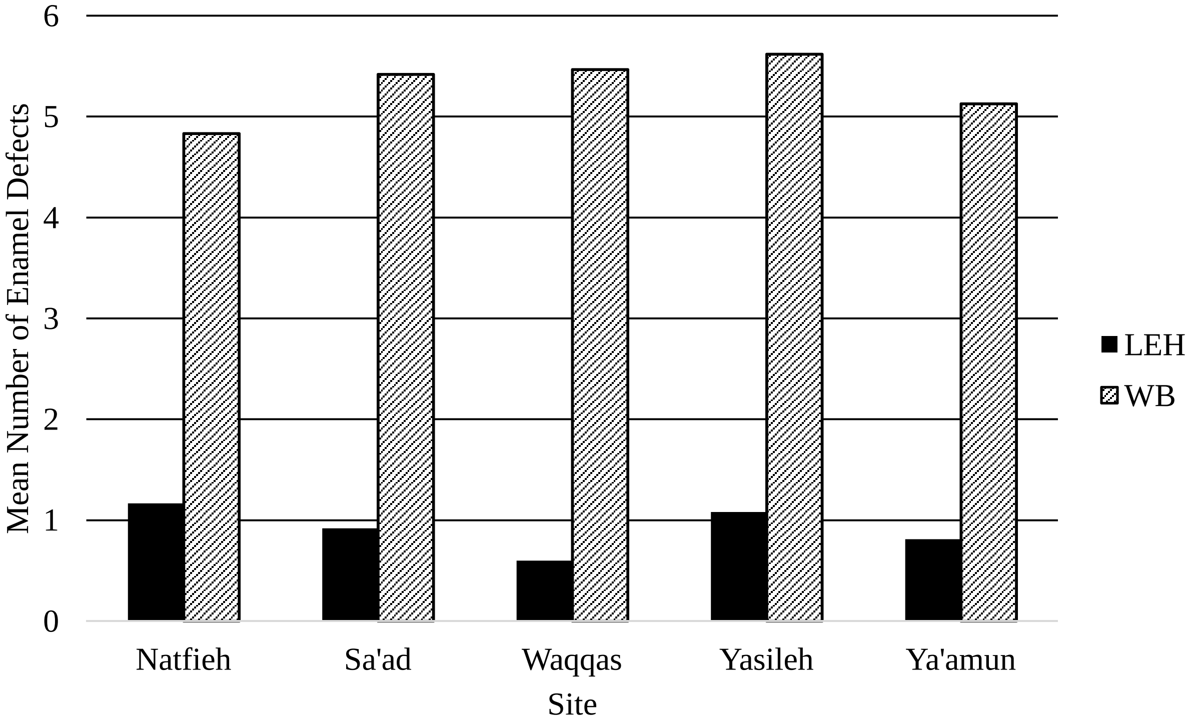


Figure 5.11: The mean number of enamel defects per individual by site.

Table 5.4: ANOVA test results for LEHs for all sites.

Source	**DF**	**Sum of Squares**	**Mean Squares**	***F* value**	***P* value**
Model	4	4.61318	1.15329	1.3107	< 0.2658
Error	319	280.68003	0.87987		
C. Total	323	285.29321			

Table 5.5: ANOVA test results for Wilson bands for all time sites.

Source	**DF**	**Sum of Squares**	**Mean Squares**	***F* value**	***P* value**
Model	4	12.2551	3.0638	.2174	< 0.9287
Error	319	4495.3838	14.0921		
C. Total	323	4507.6389			

5.5.2 Discussion

To evaluate the overall quality of life for the people who lived in Northern Jordan on the rural agricultural lands from the Bronze Age to the Byzantine it is important to gather the results from the frequencies of enamel defects by age, site, and time period.

In the first section of this chapter, the age was explored as a variable to explain frequencies of enamel defects seen. Using the ten age ranges, it was determined that around the time of weaning was the period in which children were experiencing more stress events that contributed to the formation of LEHs and Wilson bands. In the section on social and political change, those age ranges were explored further by looking at each site by time period. Weaning is a stressful period in all children's lives because of the physiological changes being imposed. Although the span of time in which canines are developing and thus recording stress is small, there are no other peaks in enamel defects to indicate that there is increased stress experienced at other age ranges across the sites and time periods.

A look at the variation between the sites while discounting the effects of time and age shows no appreciable difference in enamel defects across the sites. Waqqas is the only site in the sample that is not in the same geographical and ecological environment because it is in the Jordan Valley. The Jordan Valley tends to be warmer than the Highlands, however it does have the constant water source of the Jordan River. The statistical analysis shows no significant difference in the frequencies of enamel defects in Waqqas as opposed to the four sites on the highland plateau. The similarities between the sites suggest that there may have been no benefit to overall health by living at any particular site.

The discussion on time periods in this chapter helped to demonstrate the possible effects of climate and political change on the overall health of the children. A correlation between broad climatic changes from the Bronze Age to the Byzantine with the frequency of enamel defects could not be established. However, the statistical analysis did show an increase in the amount of Wilson bands in the Roman and Byzantine periods as compared to the Bronze Age. This suggests that the three major social and political changes occurring during the studied time frame may have had a negative impact on overall quality of life for those living in the later periods. These results indicate that the only variable that effected the populations in this sample in regards to overall quality of life was the time period in which they lived.

Chapter 6 – Conclusion

6.1 Summary

The general goal of this research was to better understand overall quality of life of the rural communities, which provided the agricultural products important to the success of the larger cities of the region. This study specifically looked at the way that these populations lived and adapted to their changing political and climatic environments. The analyses were separated into general topics that addressed the hypotheses using the enamel defect data collected from the research sample. It was possible to investigate diverse topics using the same set of data because the teeth were collected from five different sites that encompassed a time period of almost 3000 years.

The analyses were broken down so that the different variables (site location, age, and time period) could be addressed separately. The objective of the first analysis was to determine what factor age had on the likelihood of developing an enamel defect. All of the samples were combined to determine the mean number of enamel defects at each chosen age range. The objective of the second analysis was to use samples from particular time periods to see if there was a correlation between the broad climate changes in the region and the frequency of enamel defects. The objective of the third analysis was to examine the data from various time periods to identify possible stress related influences of social and political change. The final goal was to bring all of these analyses together with an analysis of the impact that site location on the frequencies of enamel defects to gain a better understanding of the overall quality of life for these populations.

This chapter begins with a summary of the major research findings based on conclusions drawn from the results of the various analyses. This section is followed by a reflection on the implications and significance of the results. The chapter ends with suggested avenues for future research.

(1) An increase in both LEHs and Wilson bands was seen in the years when weaning is expected to occur. As noted by Sellen (2006), the accelerated growth and increased caloric need contribute to increased physiological stress for all children around the time of weaning. The results of this study showed that frequency of LEHs peaked slightly before the peak in Wilson band frequency, however the average number of LEHs begins to decrease and disappear before Wilson bands. This suggests that the commencement of weaning has the most severe effect on nutrition but as weaning continues and finishes the severity of the systemic stress decreases sufficiently so that LEHs are less likely to occur.

As Wilson bands are indicators of less severe forms of physiological stress, it is expected that they will continue to develop during periods of stress even when LEHs do not form. This is confirmed in this study because the Wilson band frequency is higher overall as compared to LEHs and the duration of the increased frequency lasts longer than that for LEHs. Wilson band frequency remains high through the expected age of weaning completion and then decreases considerably.

(2) A climate shift from lower annual rainfall to higher annual rainfall has been documented within the study time period, however there is no evidence for reduced nutritional stress in the form of fewer enamel defects in the later periods. Several studies have shown a shift from a warmer and drier climate during the Bronze Age to a cooler and wetter climate during the Roman and Byzantine Empires in the Levant (Alakkam, 2002; Issar and Zohar, 2010; Rosen, 2007). It was expected that this climate change would be reflected in the reduction of enamel defects during the wetter periods. A cooler and wetter climate means better crop yields to rural agriculturalists, which should bring better nutrition and quality of life. However the results of this study show that there are significantly higher instances of enamel defects during the Byzantine period than in the Bronze Age. This suggests that climate was not a major contributing factor to the overall health and nutrition of the people in this study because the drier and warmer time period resulted in fewer average enamel defects.

(3) An increase in Wilson bands is seen in Roman and Byzantine periods as compared to the Bronze Age suggests that social and political factors had an impact on childhood stress during the later periods. With the removal of climate as a major contributing variable to overall health in this region of the Levant, it is possible to use the chosen time periods to better understand how social and political change affected the region. The population of the Levant during the Bronze Age had a low density as a result of the Bronze Age Crisis (Kaniewski et al., 2013) and drier overall climate. There is evidence for Egyptian influences (Al-Bataineh et al., 2011 a), however the populations remained small farming communities. The absence of the Iron Age and Hellenistic period from the sample leaves a gap in what can be known about the changes occurring during the first big cultural changes of the study time period. The Roman Empire brought new ideas and larger cities to the region that required increased agricultural intensification and increased sizes of rural farming communities. The Byzantine Empire brought a new religion and an ever-increasing need for agricultural products to support the large Decapolis cities. This study shows in increase in childhood stress leading to increased enamel defects during these later periods. Although the annual rainfall was the highest the region had ever seen, the social and political factors were having an adverse effect on the children of these communities.

(4) There is no evidence that living at any one site resulted in a better quality of life. The analysis of the frequency of enamel defects at the five sites of this study showed no significant difference in the number of enamel defects. Waqqas, the one site of this study in the Jordan Valley, did not exhibit any differences in enamel defects as compared to those sites on the Jordan Plateau.

With the inclusion of the results from all of the analyses conducted, this study concludes that weaning and time period had the largest effects on quality of life for these communities. The correlation across all sites and time periods showed an increase in enamel defects related to the age of weaning suggesting increased childhood stress during this period. An increased frequency of Wilson bands during the Roman and Byzantine periods as compared to the Bronze Age show a significant difference in socially and politically causative effects on childhood stress for these agricultural communities.

6.2 Significance and Implications

This study represents a significant contribution to the study of agricultural communities of the past and to the on going research of people who lived in the Levant. The area of northern Jordan that is represented in this study is unique because it has both a rich historical record and is the subject of many archaeological investigations. It lies at the crossroads of many important locations to major world empires. Because bioarchaeological research has just recently started playing an important part of the study of this region (Al-Shorman, 2006 b; Perry, 2012), it has become a useful tool for better understanding the lives of past people. Prior to the inclusion of bioarchaeological research in the Levant, archaeologists had to rely solely on historical records and archaeological analyses. Bioarchaeology has been able to test some of the assumptions that have been long held about these populations.

This study has shown that age related events like can been better understood by histological examination. Most archaeological and bioarchaeological investigation only collect data on LEHs. This research has shown that if a study is only analyzing LEH data, the analyses are missing the bigger picture seen in the Wilson band data. If only the LEH data were used in this study to determine the average age at which weaning began and ended, the estimation would have been to early in the age ranges and have lasted for a shorter duration than what is suggested in the Wilson band data.

The climate of the region has been well documented and based on this data it is easy to conclude that the people who lived during the Roman and Byzantine periods would have had a better overall quality of life. This research challenges that assumption by demonstrating that climate plays a smaller role and is eclipsed by the social and political factors. It may also be assumed that quality of life may be better during the periods ruled by the large empires, however it is important to note that an increase in childhood stress may actually be caused the social effects of these empires.

6.3 Future Research

This project highlights the need for future work in dental anthropology and types of data available through the study of dentition. Bioarchaeologists tend to specialize in areas of skeletal research. The specialized nature of dental anthropology is sometimes seen as intimidating and confusing. With better standards for data collection and the wider acceptance of dental data into bioarchaeology, a wider breadth of knowledge can be added to the study of skeletal samples. Unfortunately, dental histology requires the destruction of teeth. This is not always possible or feasible in bioarchaeological samples. Future work on ways to examine dental microstructures would improve all osteological investigations.

This research highlights only the results of this small region of the Levant. The inclusion of comparative samples from different time periods and locations would help to get a better idea of overall quality of life for this population. The scope of this research only allows for inferences about quality of life based on the sample sets (age, location, and time period), but does not allow for a wider comparison of how the overall quality of life of this population compares to other historical, prehistorical, and modern populations.

Literature Cited

Al-Asaqheirin M. 2000. Dental Bioarchaeology of Waqqas People: a Classical site in the Jordan Valley. Unpublished Thesis. Department of Anthropology, University of Arkansas, Fayetteville.

Al-Bashaireh K, Al-Shorman A, Rose JC, Jull AJT, Hodgins G. 2010. Paleodiet reconstruction of human remains from the archaeological site of Natfieh, northern Jordan. Radiocarbon 52:645–652.

Al-Bashaireh K, Al-Shorman A, Rose JC, Jull AJT. 2011. Chronological reconstruction of Natfieh tombs, northern Jordan. Palestine Exploration Quarterly 143:63–75.

Al-Bataineh M, El-Najjar MY, Burke DL. 2011a. Artifacts of Ya'mun. In: El-Najjar MY, editor. *Ya'mun: an archaeological site in Northern Jordan*. Irbid: Yarmouk University Press. p 87–108.

Al-Bataineh M, El-Najjar MY, Kizzia J, Al-Shorman A. 2011b. The tombs of Ya'mun: typology and description. In: El-Najjar MY, editor. *Ya'mun: an archaeological site in Northern Jordan.* Irbid: Yarmouk University Press. p 65–86.

Al-Muheisen Z, Al-Bashaireh K. 2012. AMS radiocarbon determination and cultural setting of the vertical shaft tomb complex at Tell al-Husn, Irbid, Northern Jordan. Palestine Exploration Quarterly 144:84–101.

Al-Muheisen Z, El-Najjar MY. 1994. An anthropological study of the human remains from Yasileh: a Classical site in Northern Jordan. Mu'tah Journal for Research and Studies 9:5–27.

Al-Muheisen Z. 1989. Yasileh. ARAM 1:253–257.

Al-Muheisen Z. 1992. Yasileh. American Journal of Archaeology 96:533–534.

Al-Obiedat A. 2002. The Analysis of Human Skeletal Remains from Ya'amun. :123.

Al-Shorman A. 2006a. Tomb reuse at Yasieleh: a Byzantine site in northern Jordan. Mediterranean Archaeology and Archaeometry 6:43–48.

Al-Shorman A. 2004a. Three cemeteries and a Byzantine Church: a ritual landscape at Yasieleh, Jordan. Antiquity 78:306–13.

Al-Shorman A. 2004b. Stable carbon isotope analysis of human tooth enamel from the Bronze Age cemetery of Ya'amoun in Northern Jordan. Journal of Archaeological Science 31:1693–1698.

Al-Shorman A. 2008. The Biology of Natfa People: Bones and Teeth. Dental Anthropology 21:18–20.

Al-Shorman A. 2007. *The archaeothanatology of Jordan*. Irbid, Jordan: Yarmouk University Press.

Al-Shorman A. 2006b. The current state of archaeological science in Jordan. Trends in Applied Sciences Research 1:61–72.

Alakkam AA. 2002. Climate Change and Archaeological Site Distribution during the Past Four Millenia in Northern Jordan Utilizing Oxygen Isotope Analysis of Human Tooth Enamel and Geographic Information System.

Aldwin CM. 2009. *Stress, Coping, and Development: An Integrative Perspective*. 2nd ed. New York: Guilford Press.

AlQahtani SJ, Hector MP, Liversidge HM. 2010. Brief communication: The London atlas of human tooth development and eruption. American Journal of Physical Anthropology 142:481–90.

Alrousan M. 2011. Dental microwear and dietary adaptation of the people of Ya'mun during the Middle/Late Bronze Age. In: El-Najjar MY, editor. *Ya'mun: an archaeological site in Northern Jordan.* Irbid, Jordan: Yarmouk University Press. p 197–208.

Antoine D, Hillson S, Dean MC. 2009. The developmental clock of dental enamel: a test for the periodicity of prism cross-striations in modern humans and an evaluation of the most likely sources of error in histological studies of this kind. Journal of Anatomy 214:45–55.

Armelagos GJ. 2003. Bioarchaeology as anthropology. Archeological Papers of the American Anthropological Association 13:27–40.

Buikstra JE, Ubelaker DH. 1994. *Standards for Data Collection from Human Skeletal Remains*. Fayetteville: Arkansas Archaeological Survey. Research Series No. 44.

Buikstra JE. 1991. Out of the Appendix and into the dirt: comments on thirteen years of bioarchaeological research. In: Powell ML, Bridges PS, Mires AMW, editors. What Mean These Bones. Tuscaloosa, AL: University of Alabama Press. p 172–188.

Buikstra JE. 1977. Biocultural Dimensions of Archaeological Study: A Regional Perspective. In: Blakely RL, editor. *Biocultural Adaptation in Prehistoric America*. Athens, GA: University of Georgia. p 67–84.

Buzon MR. 2006. Health of the non-elites at Tombos: Nutritional and disease stress in New Kingdom Nubia. American Journal of Physical Anthropology 130:26–37.

Clark Spencer Larsen. 2000. *Bioarchaeology□: interpreting behavior from the human skeleton.* 1st ed. Cambridge University Press.

Condon K, Rose JC. 1992. Intertooth and intratooth variability in the occurrence of developmental enamel defects. Journal of Paleopathology 2:61–77.

Conrad LI. 1994. Epidemic disease in central Syria in the late sixth century: Some new insights from the verse of assān ibn Thābit. Byzantine and Modern Greek Studies 18:12–59.

Davies J. 1999. *Death, Burial and Rebirth in the Religions of Antiquity.* New York: Routledge.

Djuric M, Djukic K, Milovanovic P, Janovic A, Milen P. 2011. Representing children in excavated cemeteries□: the intrinsic preservation factor. Antiquity 85:250-262.

Lester K. Little. 2007. *Plague and the end of antiquity□: the pandemic of 541-750.* 1st ed. Cambridge University Press.

Egan V, Bikai PM, Zamora K. 2000. Archaeology in Jordan. American Journal of Archaeology 104:561–588.

Eggler J. 2011. Seals. In: El-Najjar MY, editor. *Ya'mun: an archaeological site in Northern Jordan*. Irbid: Yarmouk University Press. p 33–44.

El-Najjar MY, Barnes J. 2011. Skeletal biology and pathology of the people of Ya'mun. In: El-Najjar MY, editor. *Ya'mun: an archaeological site in Northern Jordan. Irbid: Yarmouk University Press*. p 217–230.

El-Najjar MY. 2011. *Ya'mun: an archaeological site in Northern Jordan.* (El-Najjar M, Al-Bataineh M, editors.). Irbid: Yarmouk University.

Ensor BE, Irish JD. 1995. Hypoplastic area method for analyzing dental enamel hypoplasia. American Journal of Physical Anthropology 98:507–517.

Falconer S. 2001. The Middle Bronze Age. In: MacDonald B, Adams R, Bienkowski P, editors. *The Archaeology of Jordan*. Sheffield, England: Sheffield Academic Press. p 271–289.

Faust A. 2004. "Mortuary Practices , Society and Ideology": The Lack of Iron Age I Burials in the Highlands in Context. Israel Exploration Journal 54:174–190.

FitzGerald CM, Saunders SR. 2005. Test of histological methods of determining chronology of accentuated striae in deciduous teeth. American Journal of Physical Anthropology 127:277–90.

Glueck N, Burrows M, Gordon CH. 1951. Exploration in Eastern Palestine. Annual of the American Schools of Oriental Research 4.

Goodman A, Armelagos GJ, Rose JC. 1980. Enamel hypoplasias as indicators of stress in three prehistoric populations from Illinois. Human Biology 52:515–528.

Goodman AH, Armelagos GJ. 1988. Childhood Stress and Decreased Longevity in a Prehistoric Population. American Anthropologist 90:75–80.

Goodman AH, Leatherman TL. 2001. Traversing the Chasm between Biology and Culture: An Introduction. In: *Building a New Biocultural Synthesis*. Ann Arbor, MI: The University of Michigan Press. p 3–41.

Goodman AH, Rose JC. 1990. Assessment of systemic physiological perturbations from dental enamel hypoplasias and associated histological structures. American Journal of Physical Anthropology 33:59–110.

Guatelli-Steinberg D. 2010. “Growing Planes”: Incremental Growth Layers in the Dental Enamel of Human Ancestors. In: Larsen CS, editor. *A Companion to Biological Anthropology*. Oxford, Uk: Wiley-Blackwell. p 485–500.

Hassett BR. 2012. Evaluating sources of variation in the identification of linear hypoplastic defects of enamel: a new quantified method. Journal of Archaeological Science 39:560–565.

Hillson S, Bond S. 1997. Relationship of enamel hypoplasia to the pattern of tooth crown growth: a discussion. American Journal of Physical Anthropology 104:89–103.

Hillson S, Rose JC. 2012. The First Dental Pathologists and Paleopathologists. In: Buikstra JE, Roberts CA, editors. *The Global History of Paleopathology*. Oxford, UK: Oxford University Press. p 619–631.

Ibrahim M ’Awiyah, Sauer JA, Yassine K. 1976. The East Jordan Valley Survey. Bulletin of the American Schools of Oriental Research 222:41–66.

Issar AS, Zohar M. 2010. *Climate Change -: Environment and History of the Near East*. Berlin: Springer.

Jackes M. 2011. Representativeness and bias in archaeological skeletal samples. In: *Social Bioarchaeology*. Blackwell Publishing Ltd. p 107–146.

Ji C. 1995. Iron Age I in Central and Northern Transjordan: an interim summary of archaeological data. Palestine Exploration Quarterly 127:122–140.

Kaniewski D, Van Campo E, Guiot J, Le Burel S, Otto T, Baeteman C. 2013. Environmental roots of the late bronze age crisis. PloS one 8:e71004 1–10.

Katzenberg MA, Herring DA, Saunders SR. 1996. Weaning and infant mortality: Evaluating the skeletal evidence. American Journal of Physical Anthropology 101:177–199.

Khwaileh A. 1999. Dental anthropology of the Yasileh people: a classical site in Northern Jordan. Unpublished Dissertation. Department of Anthropology, University of Arkansas, Fayetteville.

King MJ. 2001. Analysis of diet in Byzantine Jordan: isotopic evidence in human dentine. Unpublished Thesis. Department of Anthropology, University of Arkansas, Fayetteville.

King T, Humphrey LT, Hillson S. 2005. Linear enamel hypoplasias as indicators of systemic physiological stress: Evidence from two known age□at□death and sex populations from postmedieval London. American Journal of Physical Anthropology 128:547–559.

Kletter R. 2013. People without Burials□? The lack of Iron I burials in the central highlands of palestine. Israel Exploration Journal 52:28–48.

Lacruz RS, Smith CE, Smith SM, Hu P, Bringas P, Sahin-Tóth M, Moradian-Oldak J, Paine ML. 2011. Chymotrypsin C (Caldecrin) is associated with enamel development. Journal of Dental Research 90:1228–1233.

Lapp PW. 1961. *Palestinian Ceramic Chronology*. New Haven: American Schools of Oriental Research.

Lewis ME. 2007. Fragile bones and shallow graves. In: *The Bioarchaeology of Children*. Cambridge: Cambridge University Press. p 20–37.

Lucke B, Schmidt M, Al-Saad Z, Bens O, Hüttl RF. 2005. The abandonment of the Decapolis region in Northern Jordan—forced by environmental change? Quaternary International 135:65–81.

MacDonald B, Adams RB, Bienkowski P. 2001. *The archaeology of Jordan.* Sheffield Academic Press.

Manzi G, Salvadei L, Vienna A, Passarello P. 1999. Discontinuity of life conditions at the transition from the Roman imperial age to the early middle ages: Example from central Italy evaluated by pathological dento-alveolar lesions. American Journal of Human Biology□ 11:327–341.

Marks MK, Rose JC, Davenport WD. 1996. Technical Note: Thin section procedure for enamel histology. American Journal of Physical Anthropology 99:493–498.

Martin SA, Guatelli□Steinberg D, Sciulli PW, Walker PL. 2008. Brief communication: Comparison of methods for estimating chronological age at linear enamel formation on anterior dentition. American Journal of Physical Anthropology 135:362–365.

McCormick M, Büntgen U, Cane MA, Cook ER, Harper K, Huybers P, Litt T, Manning SW, Mayewski PA, More AFM, Nicolussi K, Tegel W. 2012. Climate change during and after the Roman Empire□: reconstructing the past from scientific and historical evidence. Journal of Interdisciplicanry History 43:169–220.

McEwen BS. 2008. Central effects of stress hormones in health and disease: Understanding the protective and damaging effects of stress and stress mediators. European Journal of Pharmacology 583:174–185.

McNeill WH. 1976. *Plagues and Peoples.* 1st ed. Anchor.

Munro ND. 2003. Small game, the Younger Dryas, and the transition to agriculture in the southern Levant. Mitteilungen der Gesellschaft fur Urgeschichte 12:47–72.

Nanci A. 2007. *Ten Cate's Oral Histology: Development, Structure, and Function*. 7th ed. St. Louis, MO: Mosby Elsevier.

Novak M, Slaus M. 2010. Health and disease in a Roman walled city: an example of Colonia Iulia Iader. Journal of Anthropological Sciences 88:189–206.

Oxenham MF, Cavill I. 2010. Porotic hyperostosis and cribra orbitalia: the erythropoietic response to iron-deficiency anaemia. Anthropological Science 118:199–200.

Perry M. 2012. Paleopathology in Lebanon, Syria, and Jordan. In: *Global History of Paleopathology.* Oxford, UK: Oxford University Press. p 451–469.

Prowse TL, Saunders SR, Schwarcz HP, Garnsey P, Macchiarelli R, Bondioli L. 2008. Isotopic and dental evidence for infant and young child feeding practices in an imperial Roman skeletal sample. American Journal of Physical Anthropology 137:294–308.

Reid DJ, Dean MC. 2000. Brief communication: the timing of linear hypoplasias on human anterior teeth. American Journal of Physical Anthropology 113:135–9.

Reid DJ, Dean MC. 2006. Variation in modern human enamel formation times. Journal of Human Evolution 50:329–346.

Riedl N. 2003. Deities and Cults in the Decapolis. Unpublished Dissertation. Freie Universität Brelin.

Riehl S, Bryson R, Pustovoytov K. 2008. Changing growing conditions for crops during the Near Eastern Bronze Age (3000–1200 BC): the stable carbon isotope evidence. Journal of Archaeological Science 35:1011–1022.

Riehl S. 2009. Archaeobotanical evidence for the interrelationship of agricultural decision-making and climate change in the ancient Near East. Quaternary International 197:93–114.

Ritzman TB, Baker BJ, Schwartz GT. 2008. A fine line: A comparison of methods for estimating ages of linear enamel hypoplasia formation. American Journal of Physical Anthropology 135:348–361.

Rose JC, Armelagos GJ, Lallo JW. 1978. Histological enamel indicator of childhood stress in prehistoric skeletal samples. American Journal of Physical Anthropology 49:511–6.

Rose JC, Burke DL. 2004a. *Sa'ad: A Late Roman/Byzantine Site in North Jordan*. Irbid: Yarmouk University Press.

Rose JC, Burke DL. 2004b. Sa'ad: the place and its people. In: Rose JC, Burke DL, editors. *Sa'ad: a late Roman/Byzantine site in North Jordan.* Irbid, Jordan: Yarmouk University Press. p 181–187.

Rose JC, El-Najjar MY, Burke DL. 2011. Trade and the acquisition of wealth in rural late antique North Jordan. In: El-Najjar MY, editor. *Ya'mun: an archaeological site in Northern Jordan.* Irbid: Yarmouk University Press. p 239–251.

Rose JC, El-Najjar MY, Turshan N, Sari S. 1997. University of Arkansas and Yarmouk University Joint Bioarchaeological Field School at Sa'ad: preliminary report of 1996 excavations. Newsletter of the Institute of Archaeology and Anthropology Yarmouk University 20:35–37.

Rosen AM. 2007. *Civilizing Climate: social responses to climate change in the ancient Near East*. Lanham, Maryland: Altamira Press.

Rosen SA. 1993. A Roman-period pastoral tent camp in the Negev, Israel. Journal of Field Archaeology 20:441–451.

Sabel N, Klingberg G, Dietz WW, Nietzche S, Norén JG, Nietzsche S. 2010. Polarized light and scanning electron microscopic investigation of enamel hypoplasia in primary teeth. International Journal of Paediatric Dentistry / the British Paedodontic Society [and] the International Association of Dentistry for Children 20:31–6.

Sari S, Rose JC. 1995. University of Arkansas and Yarmouk University Joint Bioarchaeological Field School at Sa'ad: preliminary report of excavataions. Newsletter of the Institute of Archaeology and Anthropology Yarmouk University 18:9–11.

Sellen DW. 2006. Lactation, Complementary Feeding, and Human Life History. In: Hawkes K, Paine RR, editors. *The Evolution of Human Life History*. Santa Fe, NM: School of American Research Press. p 155–196.

Selye H. 1974. *Stress without distress*. Lippincott Williams & Wilkins.

Selye H. 1976. The stress concept. Canadian Medical Association Journal 115:718.

Shehadeh N. 1985. The climate of Jordan in the past and present. Studies in the History and Archaeology of Jordan II 35:25–37.

Stathakopoulos DC. 2004. *Famine and Pestilence in the Late Roman and Early Byzantine Empire: A Systematic Survey of Subsistence Crises and Epidemics*. Ashgate Pub Ltd.

Steckel RH, Rose JC. 2005. *The Backbone of History*. Cambridge: Cambridge University Press.

Strange J. 2001. The Late Bronze Age. In: MacDonald B, Adams R, Beinkowski P, editors. *The Archaeology of Jordan*. Sheffield, England: Sheffield Academic Press. p 291–321.

Swärdstedt T. 1966. *Odontological aspects of a Medieval population from the province of Jamtland/Mid-Sweden*. Stockholm: Tiden-Barnangen.

Temple DH. 2009. Patterns of systemic stress during the agricultural transition in prehistoric Japan. American Journal of Physical Anthropology 142:112–124.

Toynbee JMC. 1971. *Death and Burial in the Roman World*. London: Thames & Hudson.

Tucker A, Sharpe P. 2004. The cutting-edge of mammalian development; how the embryo makes teeth. Nature Reviews Genetics 5:499–508.

Ullinger JM, Sheridan SG, Hawkey DE, Turner CG, Cooley R. 2005. Bioarchaeological analysis of cultural transition in the southern Levant using dental nonmetric traits. American Journal of Physical Anthropology 128:466–76.

Vaupel JW. 1988. Inherited frailty and longevity. Demography 25:277–87.

Walker PL, Bathurst RR, Richman R, Gjerdrum T, Andrushko VA. 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.

Waterhouse SD. 1998. *Hesban 10: The Necropolis of Hesban*. Berrien Springs, Michigan: Andrews University Press.

Wheeler SM. 2012. Nutritional and disease stress of juveniles from the Dakhleh Oasis, Egypt. International Journal of Osteoarchaeology 22:219–234.

William Rosen. 2007. *Justinian's flea□: plague, empire, and the birth of Europe*. Viking.

Williams KD, El-Najjar MY, Rose JC, Al-Koufahi H, King MJ, Al-Awad F. 2004. Skeletal Biology. In: Rose JC, Burke DL, editors. *Sa'ad: a late Roman/Byzantine site in North Jordan*. Irbid: Yarmouk University Press. p 149–180.

Wilson DF, Shroff FR. 1970. The nature of the striae of Retzius as seen with the optical microscope. Australian Dental Journal 15:162–171.

Witzel C, Kierdorf U, Schultz M, Kierdorf H. 2008. Insights from the inside: Histological analysis of abnormal enamel microstructure associated with hypoplastic enamel defects in human teeth. American Journal of Physical Anthropology 136:400–414.

Wood JW, Milner GR, Harpending HC, Weiss KM, Cohen N, Eisenberg LE, Hutchinson DL, Jankauskas R, Česnys G, Katzenberg A, Lukacs JR, Mcgrath JW, Roth EA, Ubelaker DH, Wilkinson RG, Cohen MN, Cesnys G, Katzenberg MA, others. 1992. The Osteological Paradox: problems of inferring prehistoric health from skeletal samples. Current Anthropology 33:343–370.

Wright LE. 1990. Stresses of conquest: a study of Wilson bands and enamel hypoplasias in the Maya of Lamanai, Belize. American Journal of Human Biology 2:25–35.

Zuckerman MK, Turner BL, Armelagos GJ. 2011. Evolutionary thought in paleopathology and the rise of the biocultural approach. In: Grauer AL, editor. *A Companion to Paleopathology*. Oxford, UK: Wiley-Blackwell. p 34–57.

Appendix A: Enamel Defect Data

The following list provides a summary of the variables in the tables below.

1. Sample Number = Random 5 digit number assigned to each tooth.
2. Site = Site at which the individual was interred.
   a. YMN = Ya’amun
   b. SD = Sa’ad
   c. YAS = Yasileh
   d. WAQ = Waqqas
   e. NTF = Natfieh
3. Tomb Number = Given to tombs during excavation (N = Necropolis and T = Tomb).
4. Time Period = Time period in which the occupants of the tomb lived.
   a. MLB = Middle – Late Bronze Age (2,000 BC – 1,200 BC)
   b. Iron = Iron Age (1,200 BC – 332 BC)
   c. Roman = Roman Empire (63 BC – 324 AD)
   d. LRB = Late Roman – Early Byzantine (~200 – 500 AD)
   e. Byz = Byzantine Empire (324 AD – 640 AD)
5. Age Groups = Number of defects found in each age group for each tooth.
6. LEH/WB Total = Total number of defects for tooth.

Table A.1: Linear Enamel Hypoplasia Data

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	LEH Total
11000	YMN	T117	Byz	0	0	0	0	0	0	0	0	0	0	0
11004	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11005	YMN	T158	MLB	0	0	0	0	0	0	0	0	0	0	0
11017	YMN	T158	MLB	0	0	0	0	0	0	0	0	0	0	0
11024	SD	N1 T3	Byz	0	1	0	1	0	0	0	0	0	0	2
11028	SD	N1 T4	Roman	0	0	0	0	0	0	0	0	0	1	1
11032	YMN	T1	MLB	0	0	1	0	0	0	0	0	0	0	1
11036	SD	N4 T1	Byz	0	0	1	1	0	0	0	0	0	0	2
11037	SD	N4 T1	Byz	0	0	0	0	0	0	0	0	0	0	0
11039	SD	N3 C2b	Roman	0	0	0	0	0	0	0	0	0	0	0
11040	SD	N1 T4	Roman	0	0	0	0	0	0	1	0	0	0	1
11043	YMN	T3	MLB	0	0	0	1	0	0	0	0	0	0	1
11044	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11045	YAS	T26	Roman	0	0	0	0	0	0	0	0	0	0	0
11048	SD	N4 T1	Byz	0	0	0	0	0	0	0	0	0	0	0
11050	SD	N1 T4	Roman	0	0	0	1	0	0	0	0	0	0	1
11055	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11057	YMN	T1	MLB	0	0	1	1	0	1	0	0	0	0	3
11060	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11061	YAS	T35	Roman	0	0	0	0	1	0	0	0	0	0	1
11062	YAS	T358	Roman	0	0	0	0	0	0	0	0	0	0	0

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**LEH Total**
11064	SD	N4 T1	Byz	0	0	0	0	0	0	0	0	0	0	0
11065	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11066	YMN	T1	MLB	0	0	1	1	0	0	0	0	0	0	2
11067	YMN	T25	Roman	0	0	0	0	0	0	0	0	0	0	0
11070	YMN	T78	LRB	0	1	0	1	0	0	0	0	0	0	2
11071	YMN	T1	MLB	0	1	0	1	0	0	1	0	0	0	3
11075	YAS	T35	Roman	0	0	0	0	0	0	0	0	0	0	0
11077	YAS	T35	Roman	0	0	0	0	1	1	0	0	0	0	2
11084	SD	N1 T4	Roman	0	0	0	0	0	0	0	0	0	0	0
11085	YMN	T2	MLB	0	0	0	1	0	0	0	0	0	0	1
11086	SD	N1 T3	Byz	0	0	0	0	0	0	0	0	0	0	0
11087	YMN	T1	MLB	0	0	1	0	1	0	0	1	0	0	3
11098	YMN	T25	Roman	0	0	0	0	0	0	0	0	0	0	0
11101	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11102	YMN	T158	MLB	0	0	0	0	0	0	0	0	0	0	0
11109	YAS	T356	Roman	0	0	0	1	0	0	0	0	0	0	1
11110	SD	N1 T4	Roman	0	0	0	1	1	0	0	0	0	0	2
11114	YMN	T117	Byz	0	0	0	1	0	0	0	0	0	0	1
11122	YMN	T118	Byz	0	0	0	0	0	0	0	0	0	0	0
11124	YAS	T361	Roman	0	0	0	0	1	0	0	0	0	0	1
11127	YAS	T13	Roman	0	0	0	1	1	0	0	0	0	0	2
11131	SD	N4 T1	Byz	0	0	0	0	1	0	0	0	0	0	1
11132	YMN	T25	Roman	0	0	0	0	0	0	0	0	0	0	0

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**LEH Total**
11133	YMN	T1	MLB	0	0	1	0	0	0	0	0	0	0	1
11137	YMN	T78	LRB	0	0	0	0	0	0	0	0	0	0	0
11143	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11146	SD	N1 T4	Roman	0	0	0	0	1	0	0	0	0	0	1
11147	WAQ	N2 T2	Roman	0	0	0	0	0	0	0	0	0	0	0
11150	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	1
11151	YMN	T118	Byz	0	0	1	0	0	0	0	0	0	0	1
11155	YAS	T357	Roman	0	0	0	0	0	0	0	0	0	0	0
11156	SD	N4 T1	Byz	0	0	0	0	0	0	0	0	0	0	0
11157	YMN	T2	MLB	0	0	0	0	0	0	0	0	0	0	0
11160	SD	N4 T2	Roman	0	0	0	0	0	0	0	0	0	0	0
11174	SD	N1 T4	Roman	0	0	1	1	0	0	0	0	0	0	2
11179	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11180	YAS	T35	Roman	0	0	0	0	1	0	0	0	0	0	1
11181	YMN	T159	Roman	0	0	0	0	1	0	0	0	0	0	1
11183	YMN	T1	MLB	0	0	0	0	0	0	1	0	0	0	1
11186	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11187	YAS	T42	Roman	0	0	0	0	0	0	0	0	0	0	0
11188	YMN	T117	Byz	0	0	0	0	1	0	0	0	0	0	1
11192	SD	N4 T1	Byz	0	0	0	0	0	0	1	0	0	0	1
11194	YMN	T1	MLB	0	0	1	0	0	1	0	0	0	0	2
11205	NTF	T21	LRB	0	0	1	1	1	0	0	0	0	0	3
11206	NTF	T21	LRB	0	0	0	0	1	0	0	0	0	0	1

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	LEH Total
11207	YMN	T158	MLB	0	0	0	0	1	0	0	0	0	0	1
11208	YMN	T1	MLB	0	0	0	0	0	0	1	0	0	0	1
11209	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	1
11210	YMN	T158	MLB	0	0	0	1	0	0	0	0	0	0	1
11212	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11215	YAS	T35	Roman	0	0	0	0	1	0	0	0	0	0	1
11217	YMN	T158	MLB	0	0	0	1	0	1	0	0	0	0	2
11219	NTF	T55	LRB	0	0	0	1	0	0	0	0	0	0	1
11223	YMN	T1	MLB	0	0	0	0	0	1	0	0	0	0	1
11224	YMN	T45	Roman	0	0	1	0	0	0	0	0	0	0	1
11225	YMN	T116	Byz	0	0	0	0	0	0	0	0	0	0	0
11226	YMN	T207	Byz	0	0	0	0	0	0	0	0	0	0	0
11227	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11232	YMN	T158	Roman	0	0	0	0	0	0	0	0	0	0	0
11234	YMN	T117	Byz	0	0	0	0	0	0	0	0	0	0	0
11236	YMN	T78	LRB	0	0	0	0	0	0	0	0	0	0	0
11241	YMN	T158	MLB	0	0	0	0	0	1	0	0	0	0	1
11244	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11247	YAS	T361	Roman	0	0	0	1	1	0	0	0	0	0	2
11252	YMN	T78	LRB	0	0	0	1	0	0	0	0	0	0	1
11253	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11254	YAS	T26	Roman	0	0	0	0	0	0	0	0	0	0	0
11256	YMN	T106	Roman	0	0	0	0	1	0	0	0	0	0	1

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**LEH Total**
11257	YMN	T1	MLB	0	1	0	1	0	0	0	0	0	0	2
11259	YMN	T7	LRB	0	0	0	0	1	0	0	0	0	0	1
11263	YAS	T35	Roman	0	0	0	0	0	0	0	0	0	0	0
11268	YMN	T116	Byz	0	0	0	1	0	0	0	0	0	0	1
11269	YMN	T25	Roman	0	0	0	0	1	0	0	0	0	0	1
11270	YMN	T78	LRB	0	0	0	0	1	0	0	0	0	0	1
11272	YMN	T158	MLB	0	0	0	0	0	0	0	0	0	0	0
11274	YMN	T117	Byz	0	0	0	0	0	0	0	0	0	0	0
11279	SD	N1 T4	Roman	0	0	0	0	0	0	0	0	0	0	0
11280	YMN	T78	LRB	0	0	1	0	0	0	0	0	0	0	1
11282	YMN	T117	Byz	0	0	0	0	0	0	0	0	0	0	0
11284	YAS	T35	Roman	0	0	0	0	0	1	0	0	0	0	1
11285	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11286	YMN	T117	Byz	0	0	0	1	0	0	0	0	0	0	1
11293	YMN	T117	Byz	0	0	0	0	0	0	1	0	0	0	1
11295	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11296	WAQ	N2 T2	Roman	0	0	1	0	0	0	0	0	0	0	1
11297	YMN	T117	Byz	0	0	0	0	0	0	0	1	0	0	1
11299	YMN	T45	Roman	0	0	1	0	0	0	0	0	0	0	1
11301	YMN	T184	LRB	0	0	0	0	0	0	0	0	0	0	0
11302	YMN	T78	LRB	0	0	0	0	0	0	0	0	0	0	0
11305	SD	N1 T64	Roman	0	0	0	0	0	0	0	0	0	0	0
11309	YMN	T45	Roman	0	0	0	1	0	0	0	0	0	0	1

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**LEH Total**
11314	YMN	T25	Roman	0	0	0	1	0	0	0	0	0	0	1
11322	YAS	T35	Roman	0	0	1	1	0	0	0	0	0	0	2
11324	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11334	YMN	T25	Roman	0	0	0	0	0	0	0	0	0	0	0
11335	SD	N4 T1	Byz	0	1	1	1	0	2	0	0	0	0	5
11338	YMN	T1	MLB	0	1	0	0	0	0	0	0	0	0	1
11339	YAS	T361	Roman	0	0	0	1	1	0	0	0	0	0	2
11341	YMN	T117	Byz	0	0	0	1	0	0	0	0	0	0	1
11342	YAS	T357	Roman	0	0	1	1	1	0	0	0	0	0	3
11344	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11346	SD	N4 T1	Byz	0	0	1	0	0	0	0	0	0	0	1
11351	YAS	T35	Roman	0	0	0	0	1	0	0	0	0	0	1
11352	YMN	T45	Roman	0	0	0	0	0	1	0	0	0	0	1
11353	SD	N1 T4	Roman	0	0	0	0	0	0	0	0	0	0	0
11359	YMN	T193	Iron	0	0	0	0	0	0	0	0	0	0	0
11367	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11368	YMN	T25	Roman	0	0	0	0	1	0	0	0	0	0	1
11371	YAS	T35	Roman	0	0	0	1	0	0	0	0	0	0	1
11372	SD	N1 T4	Roman	0	0	0	0	0	0	0	0	0	0	0
11377	YMN	T1	MLB	0	0	0	0	1	1	0	0	0	0	2
11380	YMN	T195	Byz	0	0	0	0	0	0	0	0	0	0	0
11381	SD	N4 T1	Byz	0	0	0	0	0	0	0	0	0	0	0
11392	YMN	T25	Roman	0	0	0	1	0	0	0	0	0	0	1

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**LEH Total**
11396	YMN	T158	MLB	0	0	0	0	0	0	0	0	0	0	0
11397	YAS	T35	Roman	0	0	1	0	0	0	0	0	0	0	1
11399	YMN	T185	Byz	0	0	0	0	1	0	0	0	0	0	1
11400	YMN	T118	Byz	0	1	0	0	0	0	0	0	0	0	1
11401	YMN	T45	Roman	0	0	1	0	0	0	0	0	0	0	1
11404	YMN	T2	MLB	0	0	0	0	0	0	0	0	0	0	0
11405	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11408	YAS	T25	Roman	0	0	0	0	0	0	0	0	0	0	0
11409	YMN	T25	Roman	0	0	0	0	1	0	0	0	0	0	1
11411	SD	N1 T4	Roman	0	0	0	0	1	0	0	0	0	0	1
11412	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11414	YMN	T45	Roman	0	0	0	0	0	0	0	0	0	0	0
11416	YAS	T361	Roman	0	0	0	0	1	0	0	0	0	0	1
11417	YAS	T357	Roman	0	0	0	0	0	0	0	0	0	0	0
11418	YAS	T42	Roman	0	0	0	0	0	0	0	0	0	0	0
11419	YMN	T118	Byz	0	0	0	1	0	0	0	0	0	0	1
11421	YMN	T1	MLB	0	0	0	1	0	1	0	0	0	0	2
11424	YMN	T25	Roman	0	0	0	0	0	0	0	0	0	0	0
11425	YMN	T1	MLB	0	0	0	0	0	0	1	0	0	0	1
11427	YAS	T35	Roman	0	0	1	0	1	1	0	0	0	0	3
11428	WAQ	N2 T2	Roman	0	0	0	0	1	0	0	0	0	0	1
11429	YAS	T361	Roman	1	0	0	1	0	0	0	0	0	0	2
11432	YMN	T158	MLB	0	1	0	1	0	0	0	0	0	0	2

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**LEH Total**
11433	YMN	T184	MLB	0	0	0	1	0	0	0	0	0	0	1
11437	YMN	T158	Roman	1	0	1	1	0	0	0	0	0	0	3
11442	WAQ	N2 T2	Roman	0	0	0	0	0	0	0	0	0	0	0
11443	YMN	T184	LRB	0	0	0	0	0	0	0	0	0	0	0
11446	YAS	T35	Roman	0	0	0	0	0	0	0	0	0	0	0
11447	WAQ	N2 T2	Roman	0	0	0	1	0	0	0	0	0	0	1
11450	SD	N1 T4	Roman	0	1	0	0	1	0	0	0	0	0	2
11456	SD	N4 T1	Byz	0	0	0	0	1	0	0	0	0	0	1
11458	YMN	T1	MLB	0	1	0	0	0	0	0	0	0	0	1
11459	SD	N1 T4	Roman	0	1	0	0	0	0	0	0	0	0	1
11461	YMN	T78	LRB	0	0	0	1	1	0	1	0	0	0	3
11467	YMN	T158	MLB	0	0	1	1	1	0	0	0	0	0	3
11476	YMN	T158	MLB	0	0	0	0	0	1	0	0	0	0	1
11478	YMN	T78	LRB	0	0	0	0	0	0	0	0	0	0	0
11482	SD	N1 T4	Roman	0	0	0	1	0	0	0	0	0	0	1
11483	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11484	YAS	T35	Roman	0	0	0	1	1	0	0	0	0	0	2
11488	YMN	T117	Byz	0	0	0	1	0	0	0	0	0	0	1
11490	YMN	T185	Byz	0	0	0	0	0	0	0	0	0	0	0
11492	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	1
11493	YMN	T45	Roman	0	0	0	0	0	0	0	0	0	0	0
11494	YMN	T195	Byz	0	0	0	1	0	0	0	0	0	0	1
11495	YMN	T116	MLB	0	0	0	1	0	0	0	0	0	0	1

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	LEH Total
11498	YMN	T78	LRB	0	0	1	1	0	0	0	0	0	0	2
11501	YMN	T1	MLB	0	0	1	0	1	0	0	0	0	0	2
11505	YAS	T361	Roman	0	0	1	1	0	1	0	0	0	0	3
11506	SD	N1 T1	Roman	0	0	0	0	0	0	0	0	0	0	0
11511	YMN	T45	Roman	0	0	0	0	0	0	0	1	0	0	1
11513	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11514	YMN	T45	Roman	0	0	0	0	0	0	0	0	0	0	0
11515	YAS	T35	Roman	0	0	0	0	0	0	0	0	0	0	0
11519	YMN	T25	Roman	0	0	0	0	0	0	0	0	0	0	0
11521	WAQ	N2 T2	Roman	0	0	0	1	0	0	0	0	0	0	1
11523	YMN	T1	MLB	0	0	1	1	0	1	0	0	0	0	3
11532	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11534	YMN	T117	Byz	0	0	0	0	0	0	0	0	0	0	0
11545	YAS	T361	Roman	0	0	0	1	0	0	0	0	0	0	1
11546	YMN	T117	Byz	0	0	0	0	0	0	0	0	0	0	0
11547	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11548	WAQ	N2 T2	Roman	0	0	0	0	0	0	0	0	0	0	0
11556	YMN	T158	Roman	0	0	0	0	0	0	0	0	0	0	0
11559	SD	N1 T4	Roman	0	0	0	0	0	0	0	0	0	0	0
11560	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11561	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	1
11565	YMN	T195	Byz	0	0	0	1	0	0	0	0	0	0	1
11567	YMN	T158	MLB	0	0	0	0	0	0	0	0	0	0	0

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	LEH Total
11569	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11573	YMN	T45	Roman	0	0	0	0	0	0	0	0	0	0	0
11582	YMN	T116	Byz	0	0	0	0	0	0	0	0	0	0	0
11589	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11590	YMN	T25	Roman	0	0	0	0	0	0	0	0	0	0	0
11591	YMN	T48	Roman	0	0	0	0	0	0	0	0	0	0	0
11599	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11600	YMN	T1	MLB	0	0	1	0	1	0	0	0	0	0	2
11608	YMN	T116	Byz	0	0	0	0	0	0	0	0	0	0	0
11615	YMN	T117	Byz	0	0	1	0	0	0	0	0	0	0	1
11621	SD	N4 T1	Byz	0	0	0	0	1	0	0	0	0	0	1
11626	YMN	T158	MLB	0	0	1	0	0	0	0	0	0	0	1
11635	YMN	T158	MLB	0	0	0	1	0	0	0	0	0	0	1
11639	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11642	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11645	WAQ	N2 T2	Roman	0	0	0	0	1	0	0	0	0	0	1
11654	YMN	T1	MLB	0	0	1	0	1	0	0	0	0	0	2
11660	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	1
11662	YMN	T1	MLB	0	0	1	1	0	0	0	0	0	0	2
11663	YMN	T117	Byz	0	0	0	0	0	0	0	0	0	0	0
11668	YMN	T158	MLB	0	0	0	0	0	0	0	0	0	0	0
11669	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	1
11678	SD	N4 T1	Byz	0	0	1	0	0	1	0	0	0	0	2

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	LEH Total
11683	YMN	T1	MLB	0	0	0	0	0	1	0	0	0	0	1
11684	YMN	T1	MLB	0	0	0	1	0	1	0	0	0	0	2
11686	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11690	YMN	T158	MLB	0	0	1	1	0	0	0	0	0	0	2
11691	SD	N2 T3	Roman	0	0	0	0	0	0	0	0	0	0	0
11692	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11693	YMN	T25	Roman	0	0	0	0	0	0	0	0	0	0	0
11694	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11695	SD	N4 T1	Byz	0	0	0	0	0	1	0	0	0	0	1
11702	YAS	T35	Roman	0	0	1	0	1	0	0	0	0	0	2
11703	YMN	T158	Roman	0	0	0	0	0	0	0	0	0	0	0
11708	YAS	T361	Roman	0	0	0	0	1	0	0	0	0	0	1
11710	YMN	T78	LRB	1	0	1	1	0	0	0	0	0	0	3
11712	YMN	T158	MLB	0	1	1	0	0	0	0	0	0	0	2
11713	SD	N1 T4	Roman	0	0	0	0	0	0	0	0	0	0	0
11725	NTF	T21	LRB	0	0	0	0	1	0	0	0	0	0	1
11726	WAQ	N2 T2	Roman	0	0	0	0	1	0	0	0	0	0	1
11731	SD	N1 T4	Roman	0	0	1	0	1	0	0	0	0	0	2
11733	YMN	T158	MLB	0	0	0	1	0	0	0	0	0	0	1
11741	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	1
11742	YMN	T1	MLB	0	1	0	0	0	0	0	0	0	0	1
11744	YMN	T117	Byz	0	0	0	0	0	0	0	0	0	0	0
11745	SD	N1 T4	Roman	0	0	0	1	1	0	0	0	0	0	2

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**LEH Total**
11748	YMN	T195	Byz	0	0	0	0	0	0	0	0	0	0	0
11754	WAQ	N2 T2	Roman	0	0	0	1	0	0	0	0	0	0	1
11759	YAS	T357	Roman	0	0	0	0	1	0	1	0	0	0	2
11762	YAS	T35	Roman	0	0	0	0	1	0	0	0	0	0	1
11763	YAS	T35	Roman	0	0	0	0	0	0	0	0	0	0	0
11764	WAQ	N2 T2	Roman	0	0	0	1	0	0	0	0	0	0	1
11769	SD	N1 T4	Roman	0	0	1	1	1	0	0	0	0	0	3
11778	SD	N4 T1	Byz	0	0	0	0	0	0	0	0	0	0	0
11780	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11788	YMN	T195	Byz	0	0	0	0	0	0	0	0	0	0	0
11790	YMN	T158	MLB	0	0	0	0	0	0	0	0	0	0	0
11791	SD	N1 T4	Roman	0	0	0	1	0	0	0	0	0	0	1
11793	YMN	T158	MLB	0	0	0	1	0	1	0	0	0	0	2
11798	YMN	T3	MLB	0	1	1	0	0	0	0	0	0	0	2
11800	YAS	T35	Roman	0	0	0	0	1	0	0	0	0	0	1
11801	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11803	YMN	T116	Byz	0	0	0	0	0	0	0	0	0	0	0
11805	YMN	T117	Byz	0	0	0	0	1	0	0	0	0	0	1
11812	YAS	T361	Roman	0	1	1	0	0	0	0	0	0	0	2
11814	YMN	T117	Byz	0	0	0	0	1	0	0	0	0	0	1
11815	SD	N1 T4	Roman	0	0	0	0	0	0	0	0	0	0	0
11821	YMN	T118	Byz	0	0	0	0	0	0	0	0	0	0	0
11828	YMN	T118	Byz	0	0	1	1	0	0	0	0	0	0	2

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	LEH Total
11839	YMN	T158	MLB	0	0	0	0	1	0	0	0	0	0	1
11845	YMN	T158	MLB	0	0	0	0	1	0	0	0	0	0	1
11848	YMN	T158	MLB	0	0	0	0	1	0	0	0	0	0	1
11850	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	1
11851	YMN	T9	MLB	0	0	0	0	0	0	0	0	0	0	0
11859	SD	N1 T64	LRB	0	0	0	0	0	0	0	0	0	0	0
11867	SD	N1 T4	Roman	0	0	0	0	1	0	0	0	0	0	1
11871	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	1
11877	YAS	T35	Roman	0	0	1	1	0	0	0	0	0	0	2
11878	YMN	T158	MLB	0	1	1	1	0	0	0	0	0	0	3
11879	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11880	SD	N1 T4	Roman	0	0	0	0	1	0	0	0	0	0	1
11881	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11883	NTF	T26	Byz	0	0	0	0	0	0	0	0	0	0	0
11890	YMN	T78	LRB	0	0	0	0	0	0	0	0	0	0	0
11892	YAS	T35	Roman	0	0	1	1	0	0	0	0	0	0	2
11893	YMN	T158	MLB	0	0	0	1	0	0	0	0	0	0	1
11894	SD	N4 T1	Byz	0	0	0	0	0	0	0	0	0	0	0
11895	YMN	T185	Byz	0	0	0	1	0	0	0	0	0	0	1
11899	YAS	T35	Roman	0	0	0	0	0	0	0	0	0	0	0
11900	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11902	WAQ	N2 T2	Roman	0	0	0	0	0	0	0	0	0	0	0
11903	YAS	T361	Roman	0	0	0	0	0	0	0	0	0	0	0

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	LEH Total
11905	WAQ	N2 T2	Roman	0	0	0	0	0	0	0	0	0	0	0
11906	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	4
11908	YAS	T35	Roman	0	0	1	1	1	0	0	0	0	0	3
11911	YMN	T1	MLB	0	0	1	1	0	1	0	0	0	0	3
11912	YAS	T42	Roman	0	0	1	1	1	0	0	0	0	0	3
11920	WAQ	N2 T2	Roman	0	0	0	0	1	0	0	0	0	0	1
11922	WAQ	N2 T2	Roman	0	0	0	0	0	0	0	0	0	0	0
11926	YAS	T35	Roman	0	0	0	0	0	0	0	0	0	0	0
11931	YAS	T358	Roman	0	0	0	0	0	0	0	0	0	0	0
11935	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11937	YMN	T116	Byz	0	0	1	0	0	0	0	0	0	0	1
11938	YAS	T35	Roman	0	0	1	0	0	0	0	0	0	0	1
11940	YMN	T25	Roman	0	0	0	0	0	0	0	0	0	0	0
11942	YMN	T158	MLB	0	0	0	0	0	0	0	0	0	0	0
11944	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11955	SD	N4 T1	Byz	0	0	0	0	1	0	1	0	0	0	2
11962	YAS	T35	Roman	0	0	0	0	0	0	0	0	0	0	0
11968	YMN	T158	MLB	0	1	1	1	1	0	0	0	1	0	5
11970	NTF	T21	LRB	0	0	0	0	1	0	0	0	0	0	1
11972	SD	N1 T4	Roman	0	1	0	0	1	1	0	0	0	0	3
11975	YMN	T117	Byz	0	0	0	0	0	0	0	0	0	0	0
11977	YMN	T2	MLB	0	0	0	0	0	0	0	0	0	0	0
11978	YMN	T158	MLB	0	0	0	0	0	0	0	0	0	0	0

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**LEH Total**
11981	YMN	T1	MLB	0	0	0	1	0	0	1	0	0	0	2
11984	YMN	T1	MLB	0	0	1	1	1	0	0	0	0	0	3
11993	YMN	T198	Roman	0	0	0	0	0	0	0	0	0	0	0
11995	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11998	SD	N1 T4	Roman	0	0	0	0	1	0	0	0	0	0	1

Table A.2: Wilson Band Data

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	WB Total
11000	YMN	T117	Byz	0	0	1	0	1	1	0	0	0	0	3
11004	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11005	YMN	T158	MLB	0	1	0	0	0	2	1	0	0	0	4
11017	YMN	T158	MLB	0	0	1	0	1	1	0	1	0	0	4
11024	SD	N1 T3	Byz	1	1	2	0	0	1	1	0	1	0	7
11028	SD	N1 T4	Roman	0	0	0	1	1	1	1	0	1	0	5
11032	YMN	T1	MLB	1	0	0	1	0	0	1	0	0	0	3
11036	SD	N4 T1	Byz	0	0	1	0	0	0	0	0	1	1	3
11037	SD	N4 T1	Byz	0	1	0	0	1	0	1	0	0	0	3
11039	SD	N3 C2b	Roman	0	0	1	1	0	0	0	0	0	0	2
11040	SD	N1 T4	Roman	0	0	0	0	1	2	0	0	0	0	3
11043	YMN	T3	MLB	0	0	0	1	0	2	0	0	0	0	3
11044	YMN	T1	MLB	0	0	0	0	0	0	0	1	1	0	2
11045	YAS	T26	Roman	0	0	0	1	1	1	0	1	0	0	4
11048	SD	N4 T1	Byz	0	0	2	0	1	3	1	3	0	0	10
11050	SD	N1 T4	Roman	0	0	0	0	0	0	2	2	1	0	5
11055	YMN	T1	MLB	0	0	0	1	1	0	1	0	0	0	3
11057	YMN	T1	MLB	0	0	0	1	0	1	0	0	0	0	2
11060	YMN	T1	MLB	0	1	0	0	0	1	0	1	0	0	3
11061	YAS	T35	Roman	0	0	0	0	0	0	0	0	1	0	1
11062	YAS	T358	Roman	0	1	2	0	2	0	2	5	1	0	13

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	WB Total
11064	SD	N4 T1	Byz	0	1	2	0	1	0	2	1	1	0	8
11065	YMN	T1	MLB	0	0	0	0	1	1	0	0	0	0	2
11066	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11067	YMN	T25	Roman	0	1	0	3	3	3	1	2	2	0	15
11070	YMN	T78	LRB	0	2	0	0	0	0	1	3	0	0	6
11071	YMN	T1	MLB	0	2	0	1	2	0	1	0	1	0	7
11075	YAS	T35	Roman	0	0	0	0	0	0	0	0	0	0	0
11077	YAS	T35	Roman	0	0	0	2	1	0	0	1	1	0	5
11084	SD	N1 T4	Roman	0	0	0	0	0	1	1	0	0	0	2
11085	YMN	T2	MLB	0	0	0	3	5	1	1	0	0	0	10
11086	SD	N1 T3	Byz	0	0	0	2	2	0	1	2	0	3	10
11087	YMN	T1	MLB	0	0	0	0	0	2	1	0	0	1	4
11098	YMN	T25	Roman	0	0	0	0	2	1	0	0	0	0	3
11101	YMN	T1	MLB	0	0	0	1	1	1	2	2	0	1	8
11102	YMN	T158	MLB	0	0	0	0	0	0	1	1	2	2	6
11109	YAS	T356	Roman	0	0	1	0	1	0	0	1	0	0	3
11110	SD	N1 T4	Roman	0	0	0	0	0	0	1	2	1	1	5
11114	YMN	T117	Byz	1	0	0	0	0	0	1	0	1	0	3
11122	YMN	T118	Byz	0	0	0	0	0	1	0	0	2	0	3
11124	YAS	T361	Roman	0	0	0	1	2	0	2	0	1	2	8
11127	YAS	T13	Roman	1	1	0	0	1	0	0	0	0	0	3
11131	SD	N4 T1	Byz	0	0	0	1	0	0	0	0	0	0	1
11132	YMN	T25	Roman	0	0	0	0	1	2	2	0	0	0	5

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	WB Total
11133	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11137	YMN	T78	LRB	0	0	1	0	3	2	2	1	1		10
11143	YMN	T1	MLB	0	0	0	1	0	0	0	0	0	0	1
11146	SD	N1 T4	Roman	0	0	0	1	1	0	0	0	0	0	2
11147	WAQ	N2 T2	Roman	0	0	0	0	0	1	0	1	1	3	6
11150	YMN	T1	MLB	0	0	1	5	0	1	0	0	0	1	8
11151	YMN	T118	Byz	0	0	1	0	1	0	0	1	1	0	4
11155	YAS	T357	Roman	0	0	0	2	3	4	1	1	0	0	11
11156	SD	N4 T1	Byz	0	0	1	1	5	3	1	1	1	0	13
11157	YMN	T2	MLB	0	0	0	0	1	2	1	2	0	0	6
11160	SD	N4 T2	Roman	0	0	0	0	0	1	0	1	0	0	2
11174	SD	N1 T4	Roman	1	3	1	2	1	2	0	1	0	1	12
11179	YMN	T1	MLB	0	0	0	0	0	0	1	0	0	0	1
11180	YAS	T35	Roman	0	0	0	0	1	2	1	2	1	0	7
11181	YMN	T159	Roman	1	0	1	0	0	1	1	0	0	0	4
11183	YMN	T1	MLB	0	2	0	0	0	0	1	0	0	2	5
11186	YMN	T1	MLB	0	0	0	1	2	0	0	0	0	0	3
11187	YAS	T42	Roman	0	0	0	1	2	1	0	0	0	0	4
11188	YMN	T117	Byz	0	2	0	0	1	0	0	0	0	0	3
11192	SD	N4 T1	Byz	0	2	2	4	1	2	2	1	1	0	15
11194	YMN	T1	MLB	0	0	0	0	0	0	0	0	0	0	0
11205	NTF	T21	LRB	0	0	0	0	3	1	1	1	0	0	6
11206	NTF	T21	LRB	0	0	0	0	2	1	0	1	1	0	5

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**WB Total**
11207	YMN	T158	MLB	0	0	0	0	0	0	1	1	1	1	4
11208	YMN	T1	MLB	0	0	0	0	0	0	1	0	1	0	2
11209	YMN	T1	MLB	0	0	0	0	0	0	0	0	1	0	1
11210	YMN	T158	MLB	0	0	3	2	0	0	1	0	0	1	7
11212	YMN	T1	MLB	1	0	0	3	0	2	2	0	0	0	8
11215	YAS	T35	Roman	0	2	0	0	1	3	0	1	0	0	7
11217	YMN	T158	MLB	0	0	1	0	1	1	1	0	0	0	4
11219	NTF	T55	LRB	0	0	0	1	0	0	4	4	0	0	9
11223	YMN	T1	MLB	0	1	0	0	0	0	1	0	0	0	2
11224	YMN	T45	Roman	0	0	1	1	2	0	0	2	1	0	7
11225	YMN	T116	Byz	0	0	0	1	2	0	1	1	1	0	6
11226	YMN	T207	Byz	0	0	0	1	0	0	0	0	0	0	1
11227	YMN	T1	MLB	0	0	0	1	1	0	1	1	0	0	4
11232	YMN	T158	Roman	0	0	0	0	1	1	0	0	0	0	2
11234	YMN	T117	Byz	1	3	1	0	0	0	2	0	0	0	7
11236	YMN	T78	LRB	0	0	0	1	2	1	2	1	2	0	9
11241	YMN	T158	MLB	0	0	0	0	0	1	1	0	0	0	2
11244	YMN	T1	MLB	0	0	1	2	0	1	0	0	0	0	4
11247	YAS	T361	Roman	0	0	0	0	1	0	1	1	1	0	4
11252	YMN	T78	LRB	0	0	0	0	2	1	0	2	0	0	5
11253	YMN	T1	MLB	5	2	1	0	0	0	1	0	0	0	9
11254	YAS	T26	Roman	0	0	0	1	1	0	0	0	0	0	2
11256	YMN	T106	Roman	0	0	0	0	1	1	0	4	1	0	7

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	WB Total
11257	YMN	T1	MLB	0	0	0	1	0	1	0	0	0	0	2
11259	YMN	T7	LRB	0	0	0	0	1	1	2	1	0	0	5
11263	YAS	T35	Roman	0	0	0	0	0	1	0	3	3	0	7
11268	YMN	T116	Byz	1	0	1	0	1	0	0	1	1	0	5
11269	YMN	T25	Roman	0	0	0	1	0	0	1	1	0	0	3
11270	YMN	T78	LRB	0	0	0	0	0	0	0	1	1	0	2
11272	YMN	T158	MLB	0	0	1	0	0	0	0	0	0	0	1
11274	YMN	T117	Byz	0	0	0	0	0	0	1	1	1	0	3
11279	SD	N1 T4	Roman	0	2	2	0	0	1	0	0	0	0	5
11280	YMN	T78	LRB	0	0	2	2	4	2	1	4	1	0	16
11282	YMN	T117	Byz	0	0	1	2	1	1	0	1	0	0	6
11284	YAS	T35	Roman	0	0	0	1	0	1	2	1	1	1	7
11285	YMN	T1	MLB	0	0	0	1	1	0	0	0	0	0	2
11286	YMN	T117	Byz	0	0	0	0	0	0	2	2	0	0	4
11293	YMN	T117	Byz	0	1	0	0	0	1	0	0	0	0	2
11295	YMN	T1	MLB	0	0	1	0	0	1	0	0	0	0	2
11296	WAQ	N2 T2	Roman	0	0	3	2	7	0	1	0	1	0	14
11297	YMN	T117	Byz	0	0	0	2	1	2	1	8	0	0	14
11299	YMN	T45	Roman	0	0	4	2	7	0	1	0	1	0	15
11301	YMN	T184	LRB	0	0	0	0	1	3	1	0	0	0	5
11302	YMN	T78	LRB	0	0	0	2	1	0	1	1	1	0	6
11305	SD	N1 T64	Roman	0	0	0	1	0	1	2	1	2	0	7
11309	YMN	T45	Roman	0	0	1	1	3	2	0	1	0	0	8

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**WB Total**
11314	YMN	T25	Roman	0	1	0	2	0	0	1	0	1	0	5
11322	YAS	T35	Roman	0	0	2	1	3	1	1	0	1	1	10
11324	YMN	T1	MLB	0	0	0	0	1	0	0	1	3	0	5
11334	YMN	T25	Roman	0	0	2	0	1	3	0	2	0	0	8
11335	SD	N4 T1	Byz	0	0	0	0	0	0	0	0	1	0	1
11338	YMN	T1	MLB	0	0	2	1	3	2	1	0	0	0	9
11339	YAS	T361	Roman	0	0	0	0	2	1	0	2	1	2	8
11341	YMN	T117	Byz	0	0	0	0	0	1	1	1	0	0	3
11342	YAS	T357	Roman	0	0	0	1	1	2	1	0	0	0	5
11344	YMN	T1	MLB	0	0	0	2	0	1	2	1	1	0	7
11346	SD	N4 T1	Byz	0	0	0	0	1	0	0	0	0	0	1
11351	YAS	T35	Roman	0	0	0	0	3	2	2	0	5	0	12
11352	YMN	T45	Roman	0	0	0	1	3	1	3	2	1	0	11
11353	SD	N1 T4	Roman	0	0	0	0	2	2	3	1	0	0	8
11359	YMN	T193	Iron	0	0	0	0	1	0	1	0	0	0	2
11367	YMN	T1	MLB	0	0	0	6	1	2	0	3	5	2	19
11368	YMN	T25	Roman	0	0	0	2	2	2	1	3	1	0	11
11371	YAS	T35	Roman	0	0	1	1	0	0	0	1	0	0	3
11372	SD	N1 T4	Roman	0	0	0	0	0	1	2	2	1	1	7
11377	YMN	T1	MLB	0	1	1	2	0	2	0	0	0	0	6
11380	YMN	T195	Byz	0	0	0	0	0	1	0	1	2	0	4
11381	SD	N4 T1	Byz	0	0	0	1	1	2	2	1	0	0	7
11392	YMN	T25	Roman	0	0	0	1	1	0	1	1	1	0	5

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	WB Total
11396	YMN	T158	MLB	0	0	0	0	0	3	1	1	1	2	8
11397	YAS	T35	Roman	1	0	1	0	0	1	0	0	2	0	5
11399	YMN	T185	Byz	0	0	0	1	5	0	4	1	3	0	14
11400	YMN	T118	Byz	0	1	0	2	0	3	0	0	0	0	6
11401	YMN	T45	Roman	0	0	1	0	2	3	0	0	0	0	6
11404	YMN	T2	MLB	0	0	0	0	2	0	0	0	0	1	3
11405	YMN	T1	MLB	0	0	0	0	0	0	1	0	0	0	1
11408	YAS	T25	Roman	1	1	1	0	0	0	0	1	1	0	5
11409	YMN	T25	Roman	0	0	0	0	3	1	0	1	1	0	6
11411	SD	N1 T4	Roman	0	0	0	1	0	0	0	0	0	0	1
11412	YMN	T1	MLB	0	2	0	0	1	4	3	3	3	1	17
11414	YMN	T45	Roman	0	0	0	0	1	1	0	1	1	0	4
11416	YAS	T361	Roman	0	0	2	2	2	1	2	0	1	0	10
11417	YAS	T357	Roman	0	1	0	0	0	0	1	0	0	0	2
11418	YAS	T42	Roman	0	0	0	0	2	3	1	0	1	1	8
11419	YMN	T118	Byz	0	1	1	0	0	0	0	0	0	0	2
11421	YMN	T1	MLB	0	0	1	1	0	1	0	0	0	0	3
11424	YMN	T25	Roman	0	1	0	0	2	0	1	0	2	0	6
11425	YMN	T1	MLB	0	1	0	0	0	0	0	0	0	0	1
11427	YAS	T35	Roman	0	0	0	0	0	1	2	0	1	1	5
11428	WAQ	N2 T2	Roman	0	0	0	0	2	0	1	4	0	0	7
11429	YAS	T361	Roman	0	0	1	0	1	2	1	1	0	0	6
11432	YMN	T158	MLB	0	0	0	1	2	0	0	1	2	0	6

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	WB Total
11433	YMN	T184	MLB	0	0	0	0	0	0	0	0	2	0	2
11437	YMN	T158	Roman	1	1	1	2	1	2	0	0	0	0	8
11442	WAQ	N2 T2	Roman	0	0	2	0	1	0	1	1	1	0	6
11443	YMN	T184	LRB	0	0	0	0	2	0	1	0	0	0	3
11446	YAS	T35	Roman	0	0	1	1	0	1	0	0	0	0	3
11447	WAQ	N2 T2	Roman	0	0	0	0		1	1	3	0	0	5
11450	SD	N1 T4	Roman	0	0	0	1	2	1	2	1	2	1	10
11456	SD	N4 T1	Byz	0	0	1	0	1	3	1	2	0	0	8
11458	YMN	T1	MLB	1	1	2	0	0	1	1	0	1	1	8
11459	SD	N1 T4	Roman	0	0	0	0	0	0	0	0	0	1	1
11461	YMN	T78	LRB	0	0	0	0	0	0	0	0	1	4	5
11467	YMN	T158	MLB	0	0	0	1	0	0	0	0	3	0	4
11476	YMN	T158	MLB	0	0	2	2	1	3	1	0	0	0	9
11478	YMN	T78	LRB	0	0	0	1	3	1	2	4	0	0	11
11482	SD	N1 T4	Roman	0	0	0	1	1	0	1	1	0	0	4
11483	YMN	T1	MLB	0	0	0	0	0	0	1	1	0	0	2
11484	YAS	T35	Roman	0	0	0	0	3	1	4	1	0	0	9
11488	YMN	T117	Byz	0	0	0	1	0	0	2	1	0	1	5
11490	YMN	T185	Byz	0	0	0	0	0	0	0	0	0	0	0
11492	YMN	T1	MLB	0	0	0	2	0	0	1	0	0	1	4
11493	YMN	T45	Roman	0	1	1	0	1	0	0	3	0	0	6
11494	YMN	T195	Byz	0	0	0	0	1	0	0	0	0	0	1
11495	YMN	T116	MLB	0	0	0	1	0	0	1	0	0	0	2

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**WB Total**
11498	YMN	T78	LRB	0	0	0	1	1	0	0	0	1	1	4
11501	YMN	T1	MLB	0	0	1	1	1	1	0	1	2	1	8
11505	YAS	T361	Roman	0	1	1	0	1	0	0	2	1	3	9
11506	SD	N1 T1	Roman	0	0	1	0	0	0	0	0	2	0	3
11511	YMN	T45	Roman	0	0	0	0	1	0	1	1	0	1	4
11513	YMN	T1	MLB	0	0	2	0	0	0	1	0	1	0	4
11514	YMN	T45	Roman	0	0	0	1	1	0	0	0	0	0	2
11515	YAS	T35	Roman	0	0	1	1	0	2	0	0	1	0	5
11519	YMN	T25	Roman	0	0	0	1	1	0	0	1	1	0	4
11521	WAQ	N2 T2	Roman	0	0	0	0	0	2	1	0	0	0	3
11523	YMN	T1	MLB	0	0	1	0	0	1	0	0	0	0	2
11532	YMN	T1	MLB	0	0	0	0	0	1	0	0	0	0	1
11534	YMN	T117	Byz	0	0	0	0	1	1	0	1	1	0	4
11545	YAS	T361	Roman	0	0	0	1	0	1	1	0	2	0	5
11546	YMN	T117	Byz	0	0	2	3	1	1	1	2	0	0	10
11547	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	1
11548	WAQ	N2 T2	Roman	0	0	0	0	0	0	1	0	0	0	1
11556	YMN	T158	Roman	0	0	0	0	0	0	0	1	0	0	1
11559	SD	N1 T4	Roman	0	1	0	0	0	1	1	1	0	1	5
11560	YMN	T1	MLB	0	0	0	1	0	1	2	1	1	1	7
11561	YMN	T1	MLB	0	0	0	0	2	1	2	2	0	0	7
11565	YMN	T195	Byz	0	0	0	0	2	0	0	2	0	0	4
11567	YMN	T158	MLB	0	0	1	1	0	0	0	0	3	0	5

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	WB Total
11569	YMN	T1	MLB	0	0	1	0	2	3	0	1	0	0	7
11573	YMN	T45	Roman	0	0	0	1	1	2	2	3	2	3	14
11582	YMN	T116	Byz	0	0	2	5	5	3	1	0	0	0	16
11589	YMN	T1	MLB	0	0	1	0	0	1	0	0	0	0	2
11590	YMN	T25	Roman	0	0	0	1	0	0	2	0	0	0	3
11591	YMN	T48	Roman	0	0	1	0	1	2	2	1	1	0	8
11599	YMN	T1	MLB	0	1	0	0	0	1	2	0	1	0	5
11600	YMN	T1	MLB	0	0	0	0	1	0	0	0	0	0	1
11608	YMN	T116	Byz	0	0	0	0	1	2	3	4	0	0	10
11615	YMN	T117	Byz	0	0	0	1	0	1	0	0	2	1	5
11621	SD	N4 T1	Byz	0	0	2	0	4	2	0	2	2	0	12
11626	YMN	T158	MLB	0	0	0	1	0	2	1	0	1	1	6
11635	YMN	T158	MLB	0	1	0	0	0	0	0	0	2	2	5
11639	YMN	T1	MLB	0	0	0	0	0	0	2	1	0	0	3
11642	YMN	T1	MLB	0	0	0	0	0	0	0	1	0	0	1
11645	WAQ	N2 T2	Roman	0	0	0	1	2	2	0	2	0	0	7
11654	YMN	T1	MLB	0	0	0	0	0	3	2	1	2	1	9
11660	YMN	T1	MLB	0	0	0	0	1	1	0	1	0	0	3
11662	YMN	T1	MLB	0	0	2	0	0	0	1	0	0	2	5
11663	YMN	T117	Byz	0	1	2	0	2	3	3	1	1	3	16
11668	YMN	T158	MLB	1	1	0	1	0	0	1	0	0	0	4
11669	YMN	T1	MLB	0	0	4	3	0	2	1	0	0	0	10
11678	SD	N4 T1	Byz	0	0	0	0	0	0	0	0	0	0	0

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	WB Total
11683	YMN	T1	MLB	0	0	0	0	1	0	0	1	1	0	3
11684	YMN	T1	MLB	0	0	0	1	1	1	2	1	0	0	6
11686	YMN	T1	MLB	0	0	0	1	0	1	0	0	1	0	3
11690	YMN	T158	MLB	0	0	0	0	0	0	0	0	0	0	0
11691	SD	N2 T3	Roman	0	0	1	1	1	2	1	1	2	0	9
11692	YMN	T1	MLB	0	1	0	0	0	0	0	1	2	0	4
11693	YMN	T25	Roman	0	0	1	0	1	2	2	1	1	0	8
11694	YMN	T1	MLB	0	0	0	1	1	1	0	0	0	0	3
11695	SD	N4 T1	Byz	0	0	1	0	1	0	0	0	0	0	2
11702	YAS	T35	Roman	0	0	1	0	2	2	2	0	1	0	8
11703	YMN	T158	Roman	0	0	0	0	0	0	0	1	0	0	1
11708	YAS	T361	Roman	0	0	0	0	1	0	1	1	0	0	3
11710	YMN	T78	LRB	1	2	1	0	0	0	2	1	0	0	7
11712	YMN	T158	MLB	0	1	1	0	0	0	0	0	0	0	2
11713	SD	N1 T4	Roman	0	0	5	1	1	1	0	2	0	0	10
11725	NTF	T21	LRB	0	0	0	0	0	0	1	0	0	0	1
11726	WAQ	N2 T2	Roman	0	0	0	0	0	1	2	0	1	0	4
11731	SD	N1 T4	Roman	0	0	0	0	1	0	0	0	1	0	2
11733	YMN	T158	MLB	0	0	0	1	1	2	1	1	1	0	7
11741	YMN	T1	MLB	0	0	0	0	0	0	0	3	1	1	5
11742	YMN	T1	MLB	0	2	1	1	0	1	0	2	0	0	7
11744	YMN	T117	Byz	0	0	1	2	3	4	2	0	2	0	14
11745	SD	N1 T4	Roman	0	0	0	1	1	0	0	4	0	0	6

Sample Number	**Site**	**Tomb Number**	**Time Period**	**Age 1.5-1.7**	**Age 1.7-2.0**	**Age 1.9-2.3**	**Age 2.2-2.7**	**Age 2.7-3.1**	**Age 3.0-3.6**	**Age 3.4-4.2**	**Age 4.2-4.9**	**Age 4.8-5.6**	**Age 5.6-6.2**	**WB Total**
11748	YMN	T195	Byz	0	0	0	0	0	0	0	0	0	0	0
11754	WAQ	N2 T2	Roman	0	0	0	1	0	0	1	1	1	1	5
11759	YAS	T357	Roman	0	0	0	0	0	0	0	0	0	0	0
11762	YAS	T35	Roman	0	0	0	0	3	0	0	0	0	0	3
11763	YAS	T35	Roman	0	0	0	0	0	1	1	4	1	0	7
11764	WAQ	N2 T2	Roman	0	0	0	0	1	0	1	1	1	0	4
11769	SD	N1 T4	Roman	0	0	0	0	1	0	0	0	0	0	1
11778	SD	N4 T1	Byz	0	0	0	0	0	1	0	1	1	0	3
11780	YMN	T1	MLB	0	0	0	0	0	0	1	2	0	0	3
11788	YMN	T195	Byz	0	0	0	0	11	3	1	2	0	0	17
11790	YMN	T158	MLB	0	0	0	0	0	2	0	0	0	0	2
11791	SD	N1 T4	Roman	0	1	0	5	0	0	0	0	0	0	6
11793	YMN	T158	MLB	0	0	0	1	0	3	0	1	1	0	6
11798	YMN	T3	MLB	0	1	0	1	0	0	1	1	2	2	8
11800	YAS	T35	Roman	0	0	0	0	0	0	0	1	3	1	5
11801	YMN	T1	MLB	0	0	0	0	0	0	1	0	0	0	1
11803	YMN	T116	Byz	0	0	0	0	1	0	1	1	1	3	7
11805	YMN	T117	Byz	0	0	2	0	1	3	2	1	1	1	11
11812	YAS	T361	Roman	0	1	1	2	2	0	1	0	2	0	9
11814	YMN	T117	Byz	0	0	0	0	0	0	1	0	0	0	1
11815	SD	N1 T4	Roman	0	0	0	0	0	1	0	0	0	0	1
11821	YMN	T118	Byz	0	2	0	2	0	0	1	2	0	0	7
11828	YMN	T118	Byz	1	2	5	4	1	1	1	0	2	1	18

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	WB Total
11839	YMN	T158	MLB	0	0	0	0	1	1	0	0	0	0	2
11845	YMN	T158	MLB	0	0	0	1	0	0	0	0	0	0	1
11848	YMN	T158	MLB	0	0	0	1	1	0	1	0	0	1	4
11850	YMN	T1	MLB	0	0	0	1	0	1	0	0	0	0	2
11851	YMN	T9	MLB	1	1	0	0	0	1	0	0	2	0	5
11859	SD	N1 T64	LRB	0	0	0	2	0	0	0	0	2	0	4
11867	SD	N1 T4	Roman	0	0	0	0	0	0	1	0	0	0	1
11871	YMN	T1	MLB	0	0	0	0	1	1	2	0	0	0	4
11877	YAS	T35	Roman	0	0	0	1	0	1	0	0	0	0	2
11878	YMN	T158	MLB	0	0	1	4	4	3	3	0	0	0	15
11879	YMN	T1	MLB	0	1	0	0	0	0	0	0	0	0	1
11880	SD	N1 T4	Roman	0	1	1	0	1	0	1	0	0	1	5
11881	YMN	T1	MLB	0	0	0	0	0	0	0	2	0	0	2
11883	NTF	T26	Byz	0	0	0	0	1	0	1	0	0	0	2
11890	YMN	T78	LRB	0	0	0	0	1	0	2	0	0	0	3
11892	YAS	T35	Roman	0	0	0	1	0	0	0	0	2	1	4
11893	YMN	T158	MLB	0	0	2	1	0	0	0	0	0	0	3
11894	SD	N4 T1	Byz	0	0	2	2	4	1	1	1	0	0	11
11895	YMN	T185	Byz	0	0	0	0	0	0	1	0	4	0	5
11899	YAS	T35	Roman	0	0	0	0	4	1	1	4	1	0	11
11900	YMN	T1	MLB	0	3	0	2	0	0	1	1	0	1	8
11902	WAQ	N2 T2	Roman	0	2	1	0	0	0	0	0	0	0	3
11903	YAS	T361	Roman	0	0	1	0	0	1	0	0	2	0	4

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	WB Total
11905	WAQ	N2 T2	Roman	0	0	0	0	0	1	0	0	0	0	1
11906	YMN	T1	MLB	0	0	0	0	0	1	1	0	1	0	3
11908	YAS	T35	Roman	0	1	0	0	1	2	0	0	1	0	5
11911	YMN	T1	MLB	0	0	2	2	0	1	0	0	0	0	5
11912	YAS	T42	Roman	0	0	0	0	3	1	0	1	1	0	6
11920	WAQ	N2 T2	Roman	0	0	0	1	1	0	1	0	0	0	3
11922	WAQ	N2 T2	Roman	0	0	2	1	3	1	1	4	1	0	13
11926	YAS	T35	Roman	0	0	0	0	1	0	1	1	1	0	4
11931	YAS	T358	Roman	0	0	0	0	1	1	2	0	0	0	4
11935	YMN	T1	MLB	0	0	0	1	1	1	1	0	0	0	4
11937	YMN	T116	Byz	0	0	1	4	2	1	0	1	1	0	10
11938	YAS	T35	Roman	0	0	0	0	1	2	0	0	2	2	7
11940	YMN	T25	Roman	0	0	0	0	0	1	0	0	0	0	1
11942	YMN	T158	MLB	0	0	0	0	0	0	0	0	1	0	1
11944	YMN	T1	MLB	0	0	0	0	0	0	1	1	0	1	3
11955	SD	N4 T1	Byz	0	0	1	0	5	1	0	2	0	0	9
11962	YAS	T35	Roman	0	0	0	0	0	0	0	1	2	0	3
11968	YMN	T158	MLB	0	0	0	1	0	0	0	2	0	0	3
11970	NTF	T21	LRB	0	0	0	0	2	1	1	2	0	0	6
11972	SD	N1 T4	Roman	0	0	1	0	1	4	2	0	0	0	8
11975	YMN	T117	Byz	0	1	0	0	0	0	2	0	0	0	3
11977	YMN	T2	MLB	0	0	0	0	1	0	0	0	0	0	1
11978	YMN	T158	MLB	0	0	0	0	0	4	3	1	1	0	9

Sample Number	Site	Tomb Number	Time Period	Age 1.5-1.7	Age 1.7-2.0	Age 1.9-2.3	Age 2.2-2.7	Age 2.7-3.1	Age 3.0-3.6	Age 3.4-4.2	Age 4.2-4.9	Age 4.8-5.6	Age 5.6-6.2	WB Total
11981	YMN	T1	MLB	0	1	0	0	0	0	1	0	0	0	2
11984	YMN	T1	MLB	0	1	1	0	0	1	1	0	0	0	4
11993	YMN	T198	Roman	0	0	0	0	0	1	1	1	0	0	3
11995	YMN	T1	MLB	0	0	0	0	0	0	0	0	2	0	2
11998	SD	N1 T4	Roman	0	0	0	0	0	1	2	1	0	1	5