HEALTH AND EMPIRES: IMPLICATIONS FOR POLITICAL DEVELOPMENT ON THE HEALTH OF THE INHABITANTS OF GREAT MORAVIA (9^{TH}-10^{TH} CENTURIES)

A

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By

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By

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Abstract

The early medieval period was a time of great change in Europe. Politically thee empires ruled Europe: Charlemagne's Carolingian Empire, the Holy Roman Empire and the Byzantine Empire. During this time early cities began to form in Europe, and new patterns of settlement developed. Great Moravia was a state level society in the southeastern region of the Czech Republic during the late 9th and early 10th centuries. This thesis explores the impact of urban development on the health of its inhabitants. In order to do this, rural (Josefov and Lahovice) and urban (Mikulčice-Kostelisko) skeletal populations were examined for cribra orbitalia, porotic hyperostosis, and linear enamel hypoplasia (LEH).

Cribra orbitalia had a consistently low frequency in all populations. This suggests that anemia (often due to chronic parasitic infection and subsequent malnutrition) was present, but at a low level. LEH frequency was significantly higher, with more age of occurrence variation in the urban population. The results of this thesis suggest that despite the advantages of greater wealth and access to greater amount of food (and food varieties) urban populations were under more stress than rural populations. These results have implications about the impact of urban development and migration in modern developing nations.

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Chapter 1: Introduction

Beginning in the mid-8th century and continuing into the early 9th century, Great Moravia developed into a state level society with Mikulčice as its capital (Curta, 2009). Due to its location in the southeastern portion of the Czech Republic, it came into contact with the Frankish or Carolingian Empire, the Byzantine Empire and the Roman Papacy (Boba, 1971). The influence of these outside powers effected a period of rapid change in the society: Christianity was adopted, social stratification increased and Mikulčice developed from a fortified stronghold into a complex urban center (Barford, 2001). The health impact of these changes on the population is the focus of this study.

Figure 1: Map of medieval Europe circa 890 CE. Modified from Dvornik, (1956).

The central question posed in this thesis is if there are significant differences in health between urban and rural populations in the early medieval Czech republic.

Previous studies have shown rural populations to be under greater nutritional stress and deficiency than urban populations (Danforth, 1999; Palubeckaitė et al., 2002; Budnik and Liczbińska, 2006). The populations in the urban centers had access to food resources from multiple agricultural populations and a much larger area than the rural populations, as well as the monetary means to buy a wide range of food. As urban centers developed, however, their populations increased in size, which lead to poor sanitation and a greater concentration of communicable disease. Given the previous findings and the balancing effect of increased access to food against increased disease load, the hypothesis is that rural populations were healthier. The collections used to examine this question include three rural populations and one urban population, all dating to between the 9th and 10th centuries.

Mikulčice was one of the first urban centers in Europe to have a population over 1,000 individuals (Vélèminsky and Poláček, 2008). It was not until the middle and late medieval period that cities became common in Europe. Given its location between the three political powers in medieval Europe it is not surprising that Mikulčice developed a large population. It's location in a fertile agricultural region, and proximity to silver mines made it a prosperous area to live in. The silver mines brought merchants into the region and allowed the population to stratify to include skilled tradesmen. The influx of traders and tradesmen increased the population and also exposed them to infectious disease from widespread regions of Europe.

Sex biased access to resources has been reported in Slavic populations. Herold (2008) used stable isotope analysis to examine differences in diet between males and females in Austria populations of Avars and Slavs in the early medieval period. The results indicate that women in those populations had less access to proteins such as meat and dairy than males. Historic records also suggest that populations did not understand the nutritional needs of children in order to support growth, as food distribution recommendations indicate very small portions for children (Pearson, 1997). This would have been compounded in infants and very young children by insufficient nutrients in breast milk due to the mother not receiving enough protein.

Specific hypotheses are:

- the two rural populations will not differ significantly in frequency of non-specific health indicators
- the urban population will differ significantly from the rural populations in frequency of nonspecific health indicators
- females will differ significantly from males in all populations (urban and rural) in frequency of nonspecific health indicators

The results of this study have implications for assessing health differences in modern populations migrating to urban areas and those staying in rural areas. In particular, health and well being in developing countries is relevant, as a recent study indicated that the peasant classes in the medieval period were wealthier (in lifestyle and resources) than rural populations in developing countries (Broadberry et al., 2010). Given the association between wealth and better access to resources and health care, understanding rural versus urban health differences in a historical longitudinal model (such as medieval Europe) may prove a suitable model for assessing health trajectories associated with increased urbanization.

This thesis will be broken in to eight chapters in order to better organize the results of this research. In chapter two bioarchaeological methods will be presented. This will focus on the non-specific stress indicators accessed for this thesis, and include a review of previous studies relevant to understanding their causes. Chapter three will have a review of Slavic history focusing on Great Moravia specifically. The history and development of medieval states and urban centers will also be discussed in this chapter. Chapter three will conclude with a discussion of the political development of Great Moravia. The materials used in this thesis will be discussed in chapter four. Beginning with a discussion of the demography and geography of the sites and concluding with a discussion of the collections examined. Chapter five will discuss the methods of data collection and statistical analysis utilized in this thesis. Results from statistical analyses will be provided in chapter six. Chapter seven will focus on a discussion and interpretation of the statistical results. The final chapter in this thesis will be the conclusion, which will focus on a brief reiteration of the hypotheses of this thesis and discussion of the results.

Chapter 2: Bioarchaeological Methods

This thesis examines whether political and urban development had an impact on the health of the inhabitants of Great Moravia. Skeletal remains provide direct evidence of the lifestyles and health of past populations that can be assessed using bioarchaeological methods. In order to examine the differential impact of urbanization on medieval Moravian populations, non-specific stress indicators (i.e., cribra orbitalia, porotic hyperostosis, and linear enamel hypoplasia) were assessed using rural and urban Moravian collections from the 9-10th centuries.

2.1 Stress

Stress is a nonspecific response of the body to the demands placed upon it (Selye, 1973). When under stress the human body responds with a series of stereotypical responses that include changes to the nervous system, hormones and immune system (Selye, 1973). Selye (1973) discovered that the body undergoes three stages of response to stress. The first is the "alarm reaction" in which the body has little resistance to the stressor and overreacts as a result. During this time normal body function may decrease and growth may be interrupted. The second stage is the "resistance stage" where the body has built up a resistance to the stressor and is able to return to normal function for a period of time. The final stage is the "exhaustion stage" wherein the body no longer has the ability to resist the stressor. Once again bodily function decreases and growth may be interrupted. This stage continues until the stress ends, and the body may recover.

Developmental stress is characterized by physiological disruptions (i.e., disease, inadequate nutrition) during childhood. For example, inadequate nutrition decreases the ability of the body to produce a sufficient immune response and therefore increases susceptibility of disease (Ortner, 2003). This is particularly significant during the period of growth and developmental when additional resources are required above and beyond those required for regular health maintenance. Nutritional stress may be caused by lack of resources in the environment but can also be a result of diet and cultural customs (i.e., cultural access to resources, stratification).

Cribra orbitalia, porotic hyperostosis, and linear enamel hypoplasia (LEH) are considered to be non-specific health indicators in bioarchaeological studies. Cribra orbitalia and porotic hyperostosis have a similar etiology and therefore will be discussed together. Even though these health markers are nonspecific, and therefore are not attributable to a specific disease or process, they are still quite valuable for assessing the health of past populations.

2.2 Cribra orbitalia and porotic hyperostosis

2.2.1 Anemia. Anemia can have both genetic and environmental causes (Stuart-Macadam and Kent, 1992). Genetic anemias such as thalassemia or sickle trait are found most frequently in populations where malaria is endemic, suggesting balancing selection against malarial infection (Keenleyside and Panayotova, 2006). Genetic anemias affect the shape of red blood cells, which prevents infection by malarial-causing larvae. Environmental anemia is attributed most frequently to dietary iron deficiency. Stuart-

Macadam and Kent (1992) also suggests anemia results from chronic illness: in this instance, anemia is not caused by a lack of iron in the diet, but rather by depletion of available iron. All anemias result in subnormal hemoglobin levels in the body, which is manifest in the skeleton by a widening of the marrow cavities in the cortical bone (Kent, 1986; Stuart-Macadam and Kent, 1992) This creates an identifiable pattern of skeletal element porosity.

Parasites also have been implicated in the development of anemia (Kent, 1986; Stuart-Macadam and Kent, 1992). One such parasite is a hookworm whose presence results in reduced nutrition for the host. Stuart-Macadam and Kent (1992) proposed that the body responds to the presence of a parasite by lowering the amount of iron available in the blood stream in order to prevent it from being available to the parasite. If anemia were an adaptive response, then it would follow that perhaps a low level of anemia for a short period of time is not as harmful as previously thought. This explanation for anemia has been a subject of debate among bioarchaeologists (for a review of key issues see Holland and O'Brien, 1997). Stuart-Macadam and Kent (1992) is careful to state that this explanation for the formation of anemia does not suggest that anemia is healthy either in an extreme form or for long periods of time.

Walker et al. (2009) refute the assumption that cribra orbitalia and porotic hyperostosis are caused by iron-deficiency anemia. According to their research iron-deficiency anemia is unable to create the skeletal changes associated with cribra orbitalia and porotic hyperostosis and that megaloblastic anemia caused by vitamin B_{12} deficiency is the most likely cause of the pathologies. While adults are able to store vitamin B_{12} in their livers, children are not able to and therefore display megaloblastic anemia in greater frequency than adults. Walker et al. (2009) conclude that megaloblastic anemia is most commonly passed on from vitamin B_{12} deficient mothers to their children.

2.2.2 Skeletal evidence of anemia. Porotic hyperostosis is porosity of the skull vault caused by an expansion of the diploë and a thinning of the compact bone (Buikstra and Ubelaker, 1994; Holland and O'Brien, 1997; Ortner, 2003). Cribra orbitalia is porosity on the orbital roofs caused by the same process (Ortner, 2003). The widening of the marrow cavities in the skull, which creates an expansion of the trabecular bone and a loss of the compact bone of the skull create both conditions (Ortner, 2003). Cribra orbitalia and porotic hyperostosis have been linked to anemia (Kent, 1986; Larsen, 1997; Betsinger, 2007). Due to the lack of iron in the body the red marrow production in the trabecular bone is increased in order to produce more red blood cells. This increase in trabecular bone causes the compact bone to be resorbed in response (Ortner, 2003).

The exact relationship of porotic hyperostosis and cribra orbitalia to each other is not yet known, but they appear to have a common etiology due to their frequent co-occurrence in many populations (Betsinger, 2007). Some have theorized that porotic hyperostosis is a later stage of anemia than cribra orbitalia (Betsinger, 2007). One reason that cribra orbitalia and porotic hyperostosis are considered nonspecific health markers is that they can result from anemia of chronic disease as well as iron deficiency anemia (Kent, 1986; Stuart-Macadam and Kent, 1992). A probable reason for the higher frequency of occurrence in children than in adults is that vitamin B_{12} deficient mothers pass on their vitamin deficiency to their children while breastfeeding and therefore the children develop megaloblastic anemia (Walker et al., 2009).

2.3 Enamel defects

Enamel hypoplasias are disruptions in the enamel formation of the teeth (Goodman et al., 1984; Goodman and Armelagos, 1985). Enamel is secreted by ameloblasts during tooth formation and, due to its inorganic structure, is not subject to remodeling during life (unlike bone) (Sarnet and Schour, 1941, 1942; Goodman et al., 1984). Enamel hypoplasias can take several forms: discoloration of enamel, pitting, or horizontal bands (Goodman and Rose, 1990). The horizontal bands, called linear enamel hypoplasia (LEH) are the most frequent type of enamel defect in the archaeological record (Betsinger, 2007). Enamel hypoplasias are formed by a disruption in the enamel laying process causing insufficient enamel to be laid down due to stress or direct trauma or a genetic condition (Goodman et al., 1984). Hereditary hypoplasias are rarely reported in bioarchaeological literature. Stress caused by malnutrition or diseases are the most common causes (Hoover and Matsumura, 2008). Enamel hypoplasias are thus useful for studying the health of an individual during childhood when the teeth were forming.

LEH is particularly useful as it may be associated with a specific chronological age derived from the rigid genetic control over dental enamel development that is population specific. Goodman et al. (1984) and Reid and Dean (2000, 2006) have developed methods to estimate the age of an individual when the enamel defect formed.

Goodman et al. (1984) estimate the age of LEH occurrence by measuring the distance of the enamel defect from the cemento-enamel junction (CEJ) and entering a regression equation that is specific to each too. Reid and Dean (2000, 2006) measure total crown height and then divide the tooth vertically into 10 equally sized sections from the CEJ to the bottom of the tooth with each section assigned an age range. As enamel formation begins at the CEJ, all methods for estimating age of occurrence of LEH begin measurements there. However Goodman et al. (1984) only measure to the enamel defect rather than the overall height of the tooth crown. The advantage of this method is that incomplete or damaged teeth may be assessed. Using the Reid and Dean (2000, 2006) method with total crown height needed, only teeth that are whole, and have not experienced attrition can be used. Due to high levels of grit in food in the past, attrition was a frequent occurrence.

Goodman et al. (1984) found enamel hypoplasias occurred most frequently on the anterior teeth between the ages of two and four years. The occurrence of enamel defects in populations varies, but often coincides with the age of weaning in that culture (Goodman et al., 1984; Lanphear, 1990). Weaning stress is manifest as diarrhea that results from activation of the innate immune system in response to the shift from pathogen free mother's milk to food that often contains pathogens. Weaning diarrhea is often associated with the earliest occurrence of enamel defects in a population (Buikstra and Cook, 1980; Goodman et al., 1984). The timing of weaning is culturally dependent and influenced by diet and food processing and storage techniques.

Teeth are often used to assess childhood in past populations (Larsen, 1995). Teeth provide an indirect method of assessing overall childhood health because they span the entire period of growth and development, beginning *in utero* and finishing in adulthood with the third molars. Tooth formation periods differ by tooth position and class as well as sex (Hilson, 1979). Polar teeth (the first of a tooth class) are the most susceptible to enamel defects; but, as explained above, the anterior teeth tend to have more defects due to their development during the weaning period. Anterior teeth (incisors and canines) have more enamel defects (Goodman et al., 1984; Goodman and Rose, 1990). The maxillary and mandibular central and lateral incisors begin to form around the time of birth: enamel is continuously laid down for approximately 4-5 years following birth. The canines begin enamel formation shortly after birth and continue to develop for approximately 6 years (Goodman and Rose, 1990). Crown formation times could vary between individuals and populations (Hilson, 1979; Goodman and Rose, 1990). Due to the different but overlapping enamel formation periods, LEH on the anterior teeth is a valuable health indicator for the first several years of life.

2.4 Reconstructing health

The three health indicators discussed above are used to reconstruct the childhood health of past populations. Taken singly, cribra orbitalia, porotic hyperostosis, and LEH tell bioarchaeologists little about the health of a population but when studied together and within the context of archaeological collection, they provide a great deal of information.

Females may have a genetic buffering against stress that is not found in males (Slaus et al., 1997). This buffering allows females to better overcome or survive a stress episode. This is because the immune response of females to disease is stronger than in males (Ortner, 2003). In Slavic populations, male children received preferential treatment: this creates a balance to the possible genetic buffering of females (Slaus et al., 1997). The preferential access of males to food resources is found in many cultures (Ortner, 2003). Guatelli-Steinberg and Lukacs (1999) suggest that cultural buffering by sex-biased investment in males has a greater effect on the development of enamel defects than genetics but they find no significant differences in LEH occurrence between males and females and do not test for any genetic effect.

Previous studies on Great Moravian populations have indicated that they show biological affinity with other European populations (Vélèminsky and Poláček, 2008). This bioaffinity indicates the Slavic populations of Great Moravia had been settled there long enough to intermarry with previous populations in the region. Also it is unlikely that they will display health patterns dissimilar to other early medieval populations (Barford, 2001). In fact the Great Moravian populations showed a lower rate of caries than other medieval populations (Vélèminsky and Poláček, 2008). If Great Moravia had been classified as an empire, it is expected to see a more significant stratification between social classes and their differential access to resources than is likely to be found in a State level society.

Chapter 3: Biocultural background of Great Moravia

3.1 Slavic history

The origin of the Slavic peoples has been debated for centuries. Archaeological evidence indicates that the first inhabitants of Central Europe were Celtic Tribes (Bidleux and Jeffries, 2005). The Celts controlled the regions until the Avars began to invade Europe (Bidleux and Jeffries, 2005). The Avars were an Indo-European tribal group whose European invasions spanned several centuries. The Avars migrated into central Europe over the Carpathian Mountains but their origin prior to that migration is unknown. They were distinct from others living in Europe at the time as they spoke a language belonging to a separate language family (Bidleux and Jeffries, 2005; Ostler, 2005). In the 8th century, Charlemagne led his last major campaign against the Avars, during which it is noted that he captured a large amount of wealth to redistribute among his nobles (Sypeck, 2007).

Slavic nationalist propaganda has attempted to prove a continuous inhabitation of Central Europe dating back as far as the 5th century BCE (Bidleux and Jeffries, 2005). A map of Europe dating to 500 BCE shows that people speaking Slavic language were present in modern Poland and Lithuania, while another Slavic speaking people were present in Bulgaria (Ostler, 2005). Another attempt to prove a continuous Slavic presence in the region is based on descent from the Lusatians, an allegedly Slavic tribe (Bidleux and Jeffries, 2005). Tacitus mentioned a group of people north of the Roman Empire, who spoke a language unrelated to the Germanic tribes he studied (Ostler, 2005). While all of these are examples of ways in which Slavic governments try to prove their longevity as a people, the term Slav was first used to describe a tribe (not a language family) north of the Danube in the 6th century (Thomson, 1965).

The claims of Slavic presence in the region are not supported by archaeological evidence. According to a map of Europe dating to the early 6th century, Slavic tribes were settled in most of Central Europe (Ostler, 2005). The Slavic tribes were able to claim lands that previously belonged to the Avars through warfare and intermarriage. While some Slavic tribes were present at this time, large-scale migration of Slavic tribes into Central Europe did not begin until the 6th and 7th centuries (Sedlar, 1994; Bidleux and Jeffries, 2005). After this migration they became the dominant ethnic group in much of Central and Eastern Europe before eventually spreading north into Russia.

Linguistic evidence points to an Indo-European origin of Slavic peoples, but it cannot identify a region of origin (Thomson, 1965; Ostler, 2005). Modern Slavic language can be broken into three groups: Eastern, Western and Southern (Sedlar, 1994). Great Moravia is located within the Western subgroup, which includes modern languages such as Czech, Slovak and Polish. During the 9th century, the language spoken in the region likely held little resemblance to the modern languages. The closest representation of the Slavic languages of the time is Old Church Slavonic, which was created by Cyril and Methodius (Dvornik, 1964).

Perhaps the reason Slavic tribes were so successful in replacing the previous languages and cultures of Central and Eastern Europe was their highly organized social structure (Ostler, 2005). This social organization is evidenced in the historic and archaeological record via the quick adoption of agriculture followed by a rapid organization into a socially stratified society with craft specialization. Agriculture became increasingly advanced during the 7th century with the cultivation of wheat, millet, barley, legumes and other grains (Sedlar, 1994; Pearson, 1997). During this period, most of the settlements were hillforts, which indicated a need for protection. Due to the practice of cremation among Slavic peoples, which persisted until the 8th century, little is known about the health of these populations (Thomson, 1965). In the 8th century, cremation was no longer exclusively practice and inhumation style was flat and sometimes mound burials (Vélèminsky and Poláček, 2008). The change in burial patterns is often associated with the conversion of the Slavs to Christianity. Vélèminsky and Poláček (2008), however, reject this explanation and instead argue that complex social changes were taking place in society.

3.2 Where is Great Moravia?

Great Moravia's location in Central Europe has, at times, been a matter of debate for medieval scholars. At its largest extent, it may have stretched from southern Poland to Bulgaria (Dvornik, 1964; Curta, 2005). Imre Boba (1967, 1971) countered the agreement among scholars that Great Moravia was located north of the Danube River. Instead, Boba (1971) contends that Great Moravia was located south of the Danube River.

In his pivotal work *Moravia's History Reconsidered: A Reinterpretation of Medieval Sources* (1971), Boba outlines his argument that Moravia was a principality located in the former Yugoslavia rather than the Czech Republic. Boba's work has influenced many subsequent studies of Great Moravia with members of the scholastic community agreeing with him and others refuting his arguments. As indicated in the title of his book, Boba (1971) analyzed medieval documents regarding Great Moravia. These sources include the Frankish Annals, Bohemian Sources and Papal letters. Boba (1967, 1971) focuses on the relationship between the East Frankish Empire, the Papacy and Great Moravia in order to trace the location of Great Moravia.

Bowlus (1987, 2009) supports Boba's claims about the location of Great Moravia using corroborating evidence from the records of Arnulf of Carinthia's movements and battles as recorded in the Frankish Annals. Curta (2009) refutes both authors based on archaeological evidence that suggests that the populations of Mikulčice and neighboring Pohansko were large enough to be the center of Great Moravia. Curta contends that Boba misinterpreted archaeological evidence due to his poor understanding of the subject. Furthermore, Curta (2009) states that Boba ignored significant archaeological findings near Mikulčice and the lack of archaeological sites in the region Boba suggests Great Moravia was located in.

3.3 Great Moravian history

The Great Moravian State was only in existence for a short period. It is first referenced in the Frankish Annals in 822 CE, when Mojmir I inherited the rule (Thomson, 1965; Boba, 1971; Bidleux and Jeffries, 2005; Curta, 2005). The Frankish annals are one of the main sources of information regarding Great Moravia. Due to Great Moravia not being large enough to be a significant threat or ally it is infrequently mentioned in the annals (Boba, 1971). In 830 CE, Mojmir I drove Pribina from Nitra: this action is considered by some scholars to be the beginning of the Great Moravian State (Thomson, 1965; Bowlus, 2009). Mojmir I was succeeded by Ratislav (r. 846-870 CE) upon his death (Boba, 1971; Bidleux and Jeffries, 2005). During his reign, one of the most well known events in Great Moravian history occurred: the arrival of Byzantine missionaries Cyril and Methodius.

Great Moravia was located between the Frankish Empire and the Roman Church in the 9th and 10th centuries and was under great political pressure from both. This political pressure from the Frankish Empire may have motivated Ratislav to seek support from the Roman Church, which ignored his requests for support. In response to the lack of support from the Roman Church, Ratislav sought assistance from the Byzantine Patriarch. The Patriarch sent missionaries to Great Moravia in response (Boba, 1971). Cyril is credited with creating the first Slavic script in order to translate the Bible from Latin to the local dialect (Boba, 1971). This script eventually became Old Church Slavonic, and used Cyrillic letters, which are named in honor of Cyril's work (Dvornik, 1964). Cyril and Methodius travelled to Rome twice in order to gain Papal approval for their translations of the Bible in 868 and 869 CE (Dvornik, 1964; Vélèminsky and Poláček, 2008). While these missions were successful, Papal approval did not protect the missionaries and their students from political changes within Great Moravia.

Ratislav was deposed by his nephew Svatopluk (r. 871-894 CE) with the aid of the Franks in 871 CE (Dvornik, 1964; Bidleux and Jeffries, 2005). Svatopluk was already the ruler of another city when he assumed control of Great Moravia. Under his rule, Great Moravia underwent its greatest expansion and was frequently mentioned in the Frankish Annals (Boba, 1971). In 890 CE Svatopluk conquered Bohemia (Bowlus, 2009). After his succession, he banned the followers of Cyril and Methodius from Great Moravia as well as the use of Church Slavonic in the liturgy (Dvornik, 1964; Bidleux and Jeffries, 2005). This action may be partially a result of his alignment with the East Frankish Empire and the Roman Church; even if the Cyril and Methodius had gained Papal sanction of their texts, they and their students were associated with the Eastern Christian Church. By this time, the Frankish Empire of Charlemagne had been broken into three separate kingdoms ruled by his sons (Sypeck, 2007). The East Frankish Empire was the one with the most frequent contact with Great Moravia.

The stability of the East Frankish Empire lessened and so too did its association with Great Moravia. Arnulf of Carinthia and the East Frankish Empire and Svatopluk began their reigns with a very cordial relationship. In fact Svatopluk, was godfather and namesake to Arnulf of Carinthia's son (Boba, 1971); however, as Arnulf of Carinthia's rule began to fail, so too did the relationship between the rulers. By the end of the 9th century, the East Frankish Empire and Great Moravia were frequently at war, with both looking to expand and protect their territories (Ruttkay, 1982; Bowlus, 1987, 2009).

The decline of Great Moravia came with the invasion of the Magyars from the Asian Steppes in 906 CE (Thomson, 1965; Bidleux and Jeffries, 2005). Under attack from both the Magyars to the east and the East Frankish Empire to the west, Great

Moravia could no longer support itself and collapsed (Thomson, 1965). Great Moravia was already in decline after the death of Svatopluk due to a lack of stable leadership and the ongoing war with the East Frankish Empire.

Some authors have suggested that Arnulf of Carinthia allied himself with the Magyars in order to attack Great Moravia and end the constant warfare (Bowlus, 1987). Because each attacked Great Moravia from opposite sides during the same period, an alliance was possible, but this is merely speculation; there is no surviving evidence of such an alliance. The Magyars then went on to attack much of Europe before settling in modern Hungary, where the people still trace their linage to them.

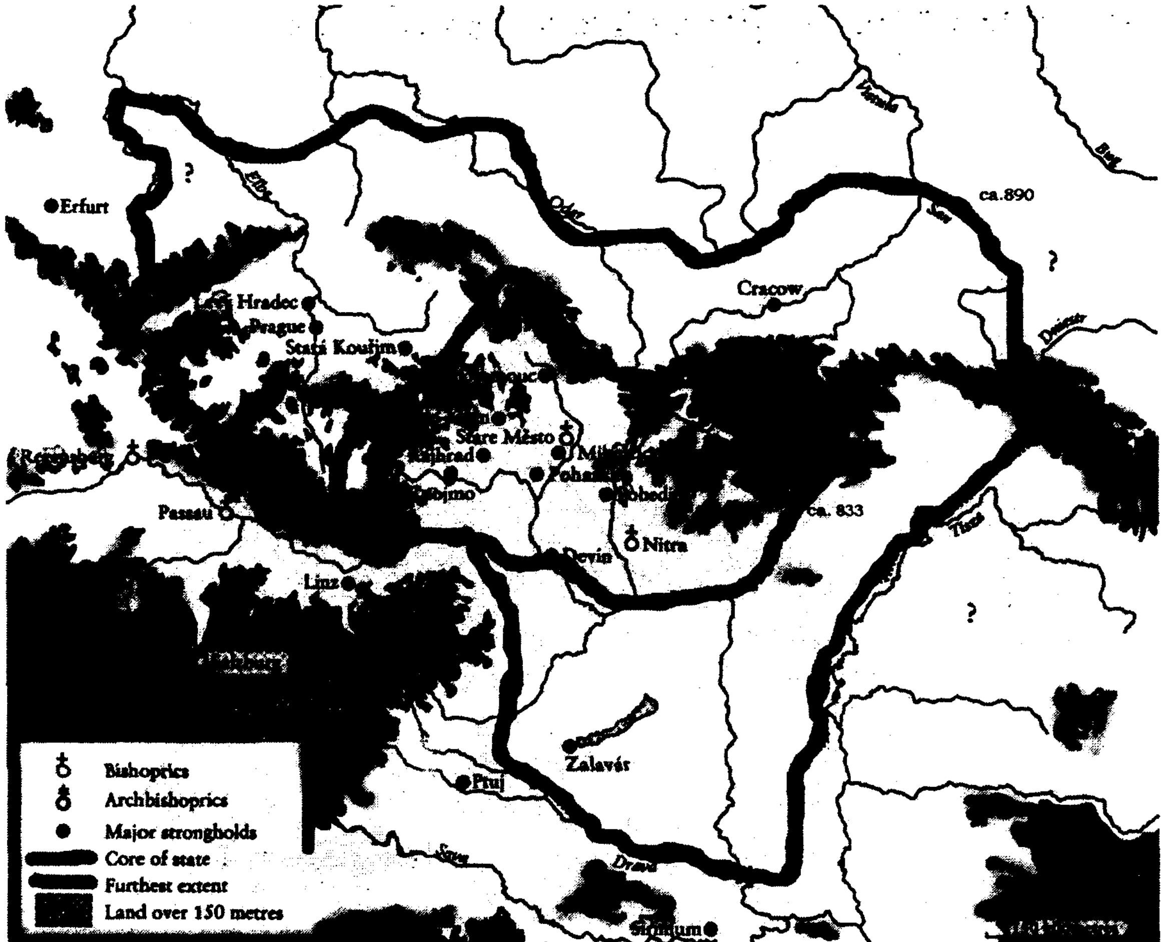

Figure 2: Map of the boundaries of Great Moravia in the 9th century. Modified from Barford (2001).

3.4 Medieval states

During the medieval period the concept of nation as state did not exist (Schulze, 1996; Curta, 2009). Nation refers to a population's sense of belonging to a particular state and its associated heritage. In order for a state to develop as a nation, a national identity and ideology must be present (Schulze, 1996). In the medieval period, the state was a very small affair (Gledhill and Bender, 1988). Often it involved only a very small territory and may have had little contact with neighboring states. The ruler did not have absolute control in the early medieval period (Schulze, 1996; Krohn-Hansen and Nustad, 2005). Schulze (1996) believes that states did not truly begin to develop in Europe until the 11th century, while Mitteis (1975) contends that they did not develop until the 13th century.

Medieval monarchs did not rule a land and its people, instead they ruled on the basis of their political relationship with nobility based upon oaths of fealty (Schulze, 1996). Mitteis (1975) defines the medieval state as an association between persons that was based upon the principle of aristocratic government. The medieval monarch never had absolute power despite their claims of that ability in the later medieval period. In fact the medieval monarch relied upon charisma and land ownership to enforce their rule (Sypeck, 2007). The support of other aristocrats and their family ties were necessary for medieval monarchs. The personal relationship between the monarch and subjects also affected the social classes during the early medieval period: indeed, during this time, a person could become a member of the aristocracy through service to the monarch or the acquisition of land (Mitteis, 1975; Schulze, 1996).

Church recognition was another important factor in the rule of a medieval monarch. The Roman Church claimed the right to anoint emperors and kings (Schulze, 1996). In the Carolingian Dynasty kings were not invested with office until the Pope had anointed them (Sypeck, 2007). Indeed, the structure of the church provided a foundation for the political structure of the medieval state (Mitteis, 1975; Gledhill and Bender, 1988). Still, while monarchs were the figureheads of the medieval state, the aristocrats and landowners controlled a great deal of the political situation.

3.5 Urban development

During the early medieval period, the climate of Europe underwent several changes. Shortly after the fall of Great Moravia in the early 10th century, Europe experienced a warming period, which lasted several centuries caused by a gradual increase in seasonal temperatures and precipitation patterns (Brázdil et al., 2005). Following the warming period Europe experienced a period of cooling temperatures and glacial expansion (Brázdil et al., 2005). The warmer temperatures during this period (compared to the 9th century) influenced agriculture and the life of the inhabitants of Great Moravia, which in turn, impacted the development of towns and urban centers. Vélèminsky and Poláček (2008) state that the conditions surrounding Mikulčice during this warming period allowed agricultural endeavors to be profitable enough to support a large population.

The designation of a site as a town has been debated among scholars with varying requirements. Hansel (1969) states that only incipient towns were present in the Czech Republic and Poland in the 9th century. He defines incipient towns as those that have inhabitants employed in a vocation other than agriculture and are transitional between an urban and rural settlement type. An example of an urban vocation is specialized craftsmanship, which began appearing among Slavic peoples by the 7th century, well before cities developed (Barford, 2001). Hansel (1969) is unable to clearly define the characteristics of an early town as he states that there is too much variation to allow for a generalization. Sedlar (1994) however contends that towns began to develop in Moravia in the 8th century, while Barford (2001) contends that towns were not present until the 13th century.

The discussion above illustrates the difficulty in identifying when towns developed in Europe. This problem is compounded by differing definitions of towns and urban centers. As the early medieval period was a time of political transition, it appears that it was also a period where changes in settlement patterns took place. These changes in settlement patterns lead to the rise of towns and urban centers where further social stratification took place. When towns first began to grow, other than size they were likely little different than their rural counterparts. Due to the similarities differentiating between rural villages and early towns can be very difficult. The difficulty is further compounded as early urban centers were closely tied to their agricultural centers, and therefore had frequent contact with rural populations (Vélèminsky and Poláček, 2008). The close relationship between urban and rural populations was present between Mikulčice and its nearby rural centers (Vélèminsky and Poláček, 2008).

Mikulčice is identified as the only investigated urban center in Central Europe from the 9th century by Hansel (1969). Mikulčice is an urban center belonging to Great Moravia that lies on the north bank of the Morava River near the southeastern border of the Czech Republic (Vélèminsky and Poláček, 2008). In the 9th century, the influence of Mikulčice would have spanned portions of Slovakia and the Czech Republic. There are few physical remains from this period that have survived to the present. The designation of Mikulčice as an urban center is perhaps the only site that several scholars agree upon

(Sedlar, 1994; Bidleux and Jeffries, 2005; Vélèminsky and Poláček, 2008). The population of Mikulčice may have been as large as 2,000 individuals, which would have been on a par with towns in the 11^{th} and 12^{th} centuries (Hansel, 1969).

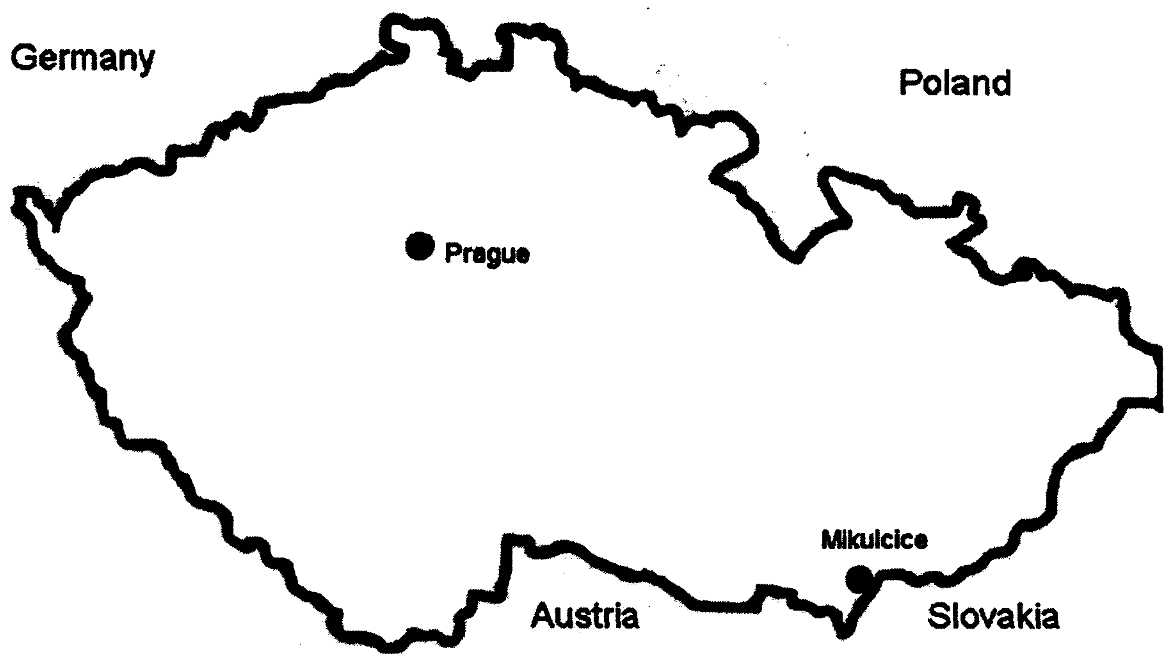

Figure 3: Map showing location of Mikulčice in the Czech Republic. Modified from Vélèminsky and Poláček (2008).

3.6 Political organization: Is Great Moravia an empire?

Some of the confusion regarding the location of Great Moravia lies in how to classify it. In the past some authors such as Dvornik (1956) have called Great Moravia an empire, while others consider it a state level society (Vélèminsky and Poláček, 2008). These contrasting names have lead to some confusion over what to call Great Moravia. Was Great Moravia an empire or a state? Great Moravia never reached the level of organization of the Holy Roman Empire nor the Byzantine Empire but it is arguably the first Slavic state level society in Europe. What criteria must be met in order for a society to be considered an empire?

Common features of empires include a writing system, monumental architecture, a large territory and a multiethnic population (Eckhardt, 1990; Alcock et al., 2001; Ostler, 2005; de L'Estoile et al., 2005). They often expand rapidly due to conquest and are tied to the concept of sovereignty (Mitteis, 1975). The term empire frequently invokes concepts such as sovereignty, domination of foreign lands and warfare (Alcock et al., 2001; Krohn-Hansen and Nustad, 2005; Pomper, 2005). The empires of interest to Great Moravia are the ancient Roman Empire, the Byzantine Empire and the Frankish Empire. All three of these empires had a lasting effect on Europe in the early medieval period (Vélèminsky and Poláček, 2008).

Subrahmanyam in Alcock et al. (2001) lists five characteristics of empires all of which are necessary for the empire to function. The first characteristic of an empire according to Subrahmanyam is an elaborate hierarchy to administer the population. Mikulčice was the largest urban center of Great Moravia, and is believed to have been the political center as well. Archaeological excavations have provided evidence of social stratification and craft specialization (Vélèminsky and Poláček, 2008).

The second characteristic of an empire is a large military to enforce imperial rule and defend the empire. Great Moravia had a military large enough to defend itself from the Frankish Empire, but its size is unknown (Ruttkay, 1982). In fact, Ruttkay (1982) found records of more than 20 war events recorded during the history of Great Moravia.

Also the presence of warrior graves with swords, axes and riding equipment have been found at nearly all Great Moravian cemeteries (Vélèminsky and Poláček, 2008).

The third characteristic of an empire is that it must be able to exercise control over a large territory. Great Moravia may have reached from Poland in the north to the former Croatia in the south at its largest (Curta, 2009). The fourth characteristic is a large subject population ruled by the empire. It is likely that Great Moravia had a large and multiethnic population. Alongside the Slavic populations would have been remnant Avars and Germanic tribes (Sedlar, 1994).

The fifth and final character is the ability to generate enough revenue to fund itself. (Vélèminsky and Poláček, 2008) state that Great Moravia was agriculturally rich, which would have been an important source of income. Archaeological evidence indicates that the Czech Republic in general, Moravia specifically, was an important source of silver for medieval Europe (Curta, 2001).

Boba (1971) addresses the question of Great Moravia's political organization by using medieval documents. According to Boba not only was Moravia not an empire; it was nothing more than a minor principality. Boba (1967, 1971) states that Papal letters to the East Frankish Empire support his claims, as does the church organization of Great Moravia. In the medieval period, bishops were assigned to cities, while archbishops were assigned to kingdoms (Mitteis, 1975). Great Moravia was home to a bishop, not an archbishop.

In addition to the Papal assignment of clergy to Great Moravia, Boba (1967, 1971) cites the Frankish Annals as referencing the Moravians as the people of a city, not a country. He reaches this conclusion based on context of the Latin words used in the Frankish Annals. Rather than using the word "Moravia" the Frankish Annals used "Maravia," which he interprets as referring to a city named Marava (Boba, 1971). Medieval documents written in Church Slavonic also support this designation of Great Moravia as a city according to Boba (1971).

The political fractionation after the death of Charlemagne may have placed enough stress on Great Moravia to allow it to become a state level society as it had to defend its territory from the East Frankish Empire and the Roman Church's authority (Alcock et al., 2001). The archaeological and historic evidence show that Great Moravia had reached a state level organization, and may have been on the path to becoming an empire but it had not yet reached that level. Great Moravia had a centralized government, social stratification, a large territory, and a multiethnic population, but it did not have the administrative capabilities to become an empire.

Therefore referring to Great Moravia as the Great Moravian Empire is both misleading and incorrect. Great Moravia encompassed several early urban centers and was ruled by a hereditary ruler. The location of Mikulčice in a fertile area near silver deposits allowed not only Mikulčice, but also nearby urban centers to grow wealthy and large. This discussion of the political capability of Great Moravia was in response to a common misnomer of calling it an empire, when it in fact was not. In deed the research has found that it was firmly in the state level society classification instead.

3.7 Conclusion

The Slavic populations in Great Moravia underwent great social, political and possibly economic change in the 9th century. The influence of being located in between three of the major political powers of the 9th century were likely a contributing factor to the social and political changes experienced. It is clear that not only did the religion of the Slavs change as they began to embrace Christianity, but it also affected their social structure and burial traditions. Social stratification became more complex during this period. The rise and fall of the Great Moravian State was influenced not only by these social changes, but also by the political environment of Europe in the 9th century.

Chapter 4: Materials

The Kostelisko, Josefov and Lahovice collections are curated by the Czech National Museum under the direction of Dr. Petr Vélèminsky.

4.1 Mikulčice and the hinterlands

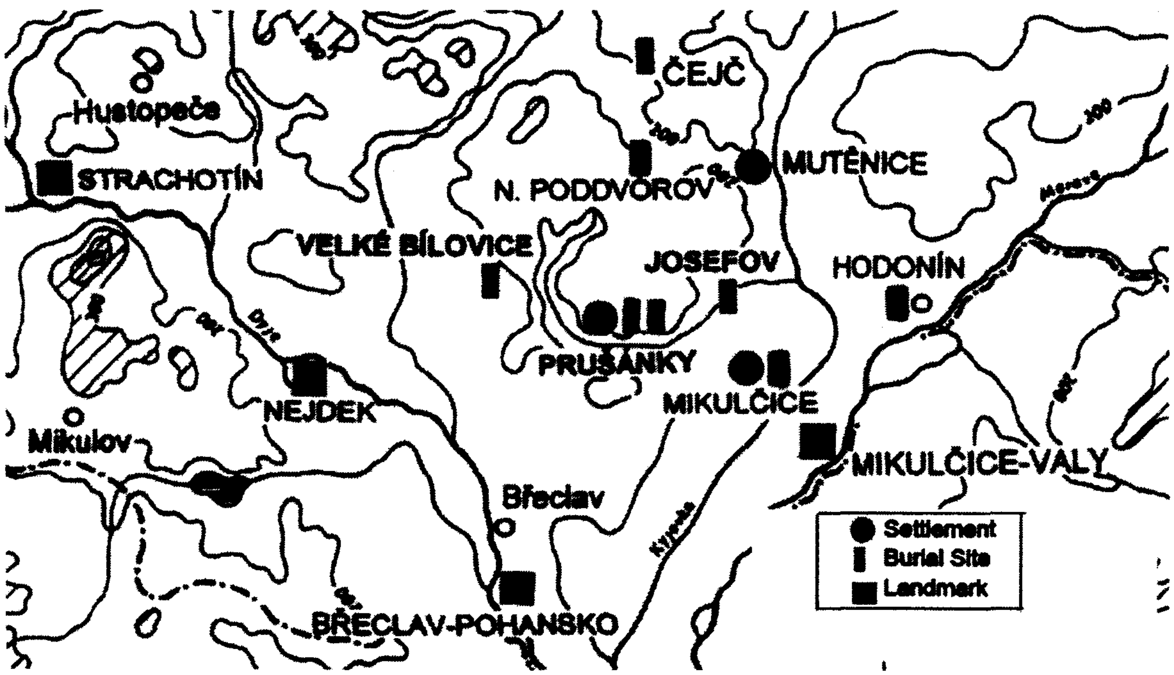

Figure 4: Map of Mikulčice and surrounding areas. Modified from Vélèminsky and Poláček (2008).

Mikulčice, the political center of Great Moravia, has the remains of more than 30 fortified settlements associated with the urban center, including one predating Great Moravia (Sedlar, 1994; Vélèminsky and Poláček, 2008). It is located on a flood plain of the Morava River where the environment would have consisted of sand dunes and woodland vegetation. Thus, early settlements would have been located on top of the sand dunes with later settlements expanding into the lower regions over time (Vélèminsky and Poláček, 2008).

The difference between the royal area and other residential areas provides clear evidence of social stratification (Sedlar, 1994; Bidleux and Jeffries, 2005; Vélèminsky and Poláček, 2008). Mikulčice had a royal residence that had four churches, which include the basilica, a palace, and a large cemetery. Surrounding the royal area were the different regions of the city. There are nine churches in Mikulčice, the majority of which are surrounded by cemeteries. The layout of the cemeteries clearly display the social status of the individuals buried there: those with high status were buried closest to the church, which also reflects the widespread adoption of Christianity in the population (Barford, 2001; Vélèminsky and Poláček, 2008).Further evidence of the Christian influence is in the reduction of grave goods that are forbidden in Christian burials. Prior to the Christianization of the population, common grave goods included spurs, jewelry and weapons.

Vélèminsky and Poláček (2008) state that some of the cemeteries were in use even after the Great Moravian state no longer existed. The cemeteries of Great Moravia are most frequently associated with churches, but they can also be associated with strongholds. The burials are organized in irregular rows and may include complex burials with coffins or simple pit graves (Effros, 1997; Vélèminsky and Poláček, 2008).

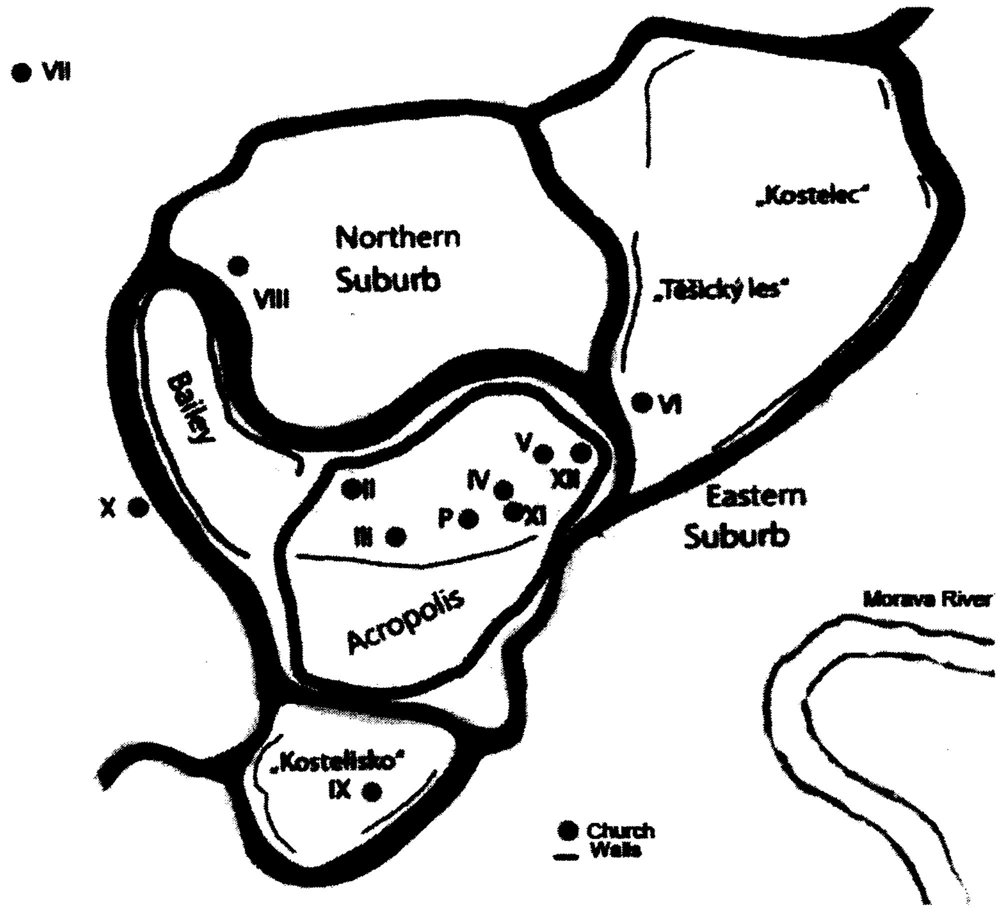

Figure 5: Map of Mikulčice with suburbs. Modified from Vélèminsky and Poláček (2008).

While extensive research has been conducted on the urban centers of Great Moravia such as Mikulčice, Mikulčice-Valy and Pohansko, there are more than just urban centers in Great Moravia. Vélèminsky and Poláček (2008) define the hinterlands as an area within a radius of 10 kilometers from the urban center. This area would only have supported 1,000-2,000 inhabitants based on the agricultural conditions of his estimation. Knowledge of these regions comes exclusively from archaeological excavations, as there are no written sources for these regions.

The lack of written records led many to suggest that those living in the hinterlands were of poorer socio-economic status, but archaeological data has not supported this hypothesis (Vélèminsky and Poláček, 2008). The hinterland burial sites share several important characteristics. The number of burials suggests a much smaller population at these sites than at the urban centers. A much higher proportion of the graves have grave goods, although the selection of items found in the graves is simplified in comparison with the urban centers. In fact, the presence of "warrior" graves typified by weapons and riding equipment has been found in the hinterlands as well as in the urban centers. Instead of swords, the "warrior" graves are most likely to contain axes as swords were expensive to produce and would be passed down in families (Vélèminsky and Poláček, 2008).

Even if the hinterlands represented poor populations, they would not be the lowest social classes in Great Moravian society. Slaves were present in Slavic society in the 9th century (Sedlar, 1994; Curta, 2003). Both Sedlar (1994) and Curta (2003) discuss the evidence of slaves being present in Europe, and specifically in Slavic societies well into the medieval period. According to Curta (2003), Moravia became an important source for supplying slaves to other parts of Europe after the 10th century. Sedlar (1994) states that the presence of slaves in Slavic society does not indicate an early form of serfdom, which became common throughout Europe in the medieval period. Supplying slaves was not the main source of contact with outside cultures during this period, which was warfare and trade.

4.2 Collections

Kostelisko is a suburb of Mikulčice located on the southern side near church IX. Evidence indicates that the individuals buried at this location were of some of the highest status (Sedlar, 1994; Vélèminsky and Poláček, 2008). A total of 415 burials have been found (Vélèminsky and Poláček, 2008). It is the largest collection examined, with the best preservation.

Josefov is a hinterland site located seven kilometers from Mikulčice. It has yielded 178 burials, which makes it the largest hinterland site (Stranska et al., 2002; Vélèminsky and Poláček, 2008). Demographic indicators such as a large proportion of older women led Vělěminsky and Poláček (2008) to conclude that it was not a poor population. The large number of juvenile graves also suggests a very fertile population present (Stranska et al., 2002). Stranska et al. (2002) states that the demography represents several social classes, and the population corresponds well to Kostelisko in this regard. The population was not as affluent as Kostelisko. This lower level of affluence is reflected in burial goods that are more likely to include simple pottery, and display less variety than those of Kostelisko (Stranska et al., 2002; Vélèminsky and Poláček, 2008). The collection preservation was generally poor. Due to the presence of bronze jewelry among grave goods, skeletal remains were occasional stained green on the skull where the jewelry was placed.

Lahovice was the final collection examined. Excavations took place over six years (1954 to 1960) at a location outside of Prague, Czech Republic Four-hundred and three graves were found (Likovsky et al., 2005). Very little information is available about this site and preservation is poor. Many of the teeth were glued together, which prevented measurement of the molars for analysis.

4.2.1 Demographics A total of 1,079 individuals comprise the total sample size. Urban Kostelisko comprises 474 individuals making up 43.9% of the total sample size studied for this thesis. Rural Josefov comprises 18.7% of the sample size (N = 202), while rural Lahovice comprises 37.3% of total sample size (N=403). Subadults comprise 43.3% of the sample size (N=467). Female comprise 309 individuals (28.6%), while males comprise 200 individuals (18.5%). 103 individuals of unknown sex comprise 9.5% of the total sample size. 204 infants make up 18.9% of the sample, while 228 children make up 21.1% of the total sample size. Finally 603 adults make up 56.1% of the sample studied and 41 individuals (3.3%) have no age estimates most likely due to poor preservation.

Table 1: Demographic breakdown by age of all sites

			Frequency	Percent
Kostelisko		infant	34	7.2
		child	158	33.3
		adult	253	53.4
	Missing		29	6.1
		Total	474	100
Josefov		infant	32	15.8
		child	59	29.2
		adult	107	53
	Missing		4	2
		Total	202	100
Lahovice		infant	138	34.2
		child	11	2.7
		adult	246	61
	Missing		8	2
		Total	403	100

Chapter 5: Methods

5.1 Hypotheses

The following hypotheses will be tested using the methods described in this chapter.

- the two rural populations will not differ significantly in frequency of non-specific health indicators
- the urban population will differ significantly from the rural populations in frequency of nonspecific health indicators
- females will differ significantly from males in all populations (urban and rural) in frequency of nonspecific health indicators

5.2 Data collection

The author examined these collections in June and July of 2010. The collections comprising 1,079 individuals were examined for the presence of LEH, cribra orbitalia and porotic hyperostosis. Buikstra and Ubelaker (1994) definitions were used as the standard for the determination of LEH, cribra orbitalia and porotic hyperostosis. Skeletal remains were first examined for the presence of cribra orbitalia and porotic hyperostosis. Then teeth were examined for LEH and measurements were taken if present. All information was recorded before LEH measurements were rechecked. Measurements for LEH were taken twice on two separate data collection trails to ensure accuracy.

5.3 Cribra orbitalia

Cribra orbitalia was recorded as presence or absence of evidence of remodeling in the orbital roofs when at least one orbit was present. Whenever possible, the presence of cribra orbitalia was confirmed on both orbital roofs. The author was conservative in determining the presence of cribra orbitalia due to the effects of weathering and preservation on the skeletal remains.

5.4 Porotic hyperostosis

The presence or absence of porotic hyperostosis was scored for porosity when at least one parietal bone was intact. Whenever possible the diagnosis was confirmed on both parietals. The author was conservative in determining the presence of porotic hyperostosis.

5.5 Linear enamel hypoplasia

LEH presence was recorded as present when enamel defects were visible macroscopically and palpable with a fingernail (Goodman and Rose, 1990). Whenever possible the presence of LEH was confirmed on the both antimeres. The age of the individual when the hypoplastic event occurred was estimated by measuring the distance of the LEH from the CEJ on the anterior teeth (Goodman and Rose, 1990). The Goodman and Rose (1990) method was selected instead of the Reid and Dean (2000, 2006) because total crown height was not collected due to attrition in the population, which would have made crown heights suspect. Digital calipers were used to measure the distance of LEH from CEJ in millimeters.

5.6 Statistics

Binary data was recorded so the chi-square goodness of fit statistic in crosstabs was used to determine whether there were significant differences between rural populations and also between pooled rural populations (Josefov and Lahovice) and the urban population with regards to the frequency of cribra orbitalia, porotic hyperostosis and LEH occurrence. Symmetrical measures (Phi and Cramer's V) tested the strength of association by two-tailed chi-square results. These statistics are particularly useful in instances where the p-value exceeds .05, but is less than .10. The phi also is more statistically robust in small populations (Hoover and Matsumura, 2008).

The chi-square statistic was then used to determine whether there were significant differences between rural populations and between the pooled rural and the urban population in age of LEH occurrence. All statistical analyses were carried out on PASW® 18.0.

Table 2: Chart showing regression equation for estimation of LEH age of occurrence. Modified from Goodman and Rose (1990).

		Formulae
Maxillary Teeth	Central Incisor	Age= -(.454xHt)+4.5
	Lateral Incisor	Age= -(.402xHt)+4.5
	Canine	Age= -(.625xHt)+6.0
Madibular Teeth	Central Incisor	Age= -(.460xHt)+4.0
	Lateral Incisor	Age= -(.417xHt)+4.0
	Canine	Age- =(-.588xHt)+6.5

Age= age in years, Ht= distance of the LEH in mm from CEJ

5.7 Pooled rural populations

A chi-square test showed no significant differences between rural populations. The lack of significant differences may have been a product of small sample size. With that caveat in mind the samples were combined to create a larger sample size.

Chapter 6: Results

6.1 Cribra orbitalia

Cribra orbitalia presence was observed in 30 (14.7%) infant, 109 (47.8%) child and 392 (64.7%) adult remains from all collections studied. No statistical significance was found for cribra orbitalia occurrence between the urban and rural sites.

Table 3: Cribra orbitalia frequencies by site

			Frequency	Percent
Kostelisko		Absent	239	50.4
		Present	23	4.9
		Total	262	55.3
	Missing		212	44.7
		Total	474	100
Josefov		Absent	95	47
		Present	8	4
		Total	103	51
	Missing		99	49
		Total	202	100
Lahovice		Absent	162	40.2
		Present	5	1.2
		Total	167	41.4
	Missing		236	58.6
		Total	403	100

Table 4: Cribra orbitalia frequency between urban and rural sites

			Percent
Urban		Infants	0
		Children	22.85
		Adults	3.29
		Total	26.14
	Missing		73.86
Rural		Infants	23.8
		Children	15.38
		Adults	0.09
		Total	39.27
	Missing		60.73

6.1.1 By age-at-death. When cribra orbitalia frequency was compared to age-at-death for Kostelisko (urban) and Lahovice (rural) the chi-square results were highly significant (p=.000). At Josefov (rural) the results were also significant (p=.013).

Table 5: Chi-square results of cribra orbitalia frequency for sites compared by age

		Value	df	Asymp. Sig. (2-sided)
Kostelisko	Pearson Chi-Square	25.918[a]	2	0
	Likelihood Ratio	22.921	2	0
	Linear-by-Linear Association	12.454	1	0
	N of Valid Cases	261		
Josefov	Pearson Chi-Square	8.698[b]	2	0.013
	Likelihood Ratio	8.902	2	0.012
	Linear-by-Linear Association	7.938	1	0.005
	N of Valid Cases	103		
Lahovice	Pearson Chi-Square	29.511[c]	2	0
	Likelihood Ratio	14.966	2	0.001
	Linear-by-Linear Association	27.223	1	0
	N of Valid Cases	167		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is .76.

b. 4 cells (66.7%) have expected count less than 5. The minimum expected count is .39.

c. 4 cells (66.7%) have expected count less than 5. The minimum expected count is .12.

6.1.2 By sex. When cribra orbitalia presence was tested against sex at the sites 1.8% of females and 6.45% of males at Kostelisko (urban) displayed cribra orbitalia. At Josefov (rural) 2.6% of females and no males displayed cribra orbitalia. At Lahovice (rural) no female and 1.5% of males had cribra orbitalia present. Chi-square test results suggest there is no significance difference within sites.

6.2 Porotic hyperostosis

Only three cases of porotic hyperostosis were present in the collections studied. Two of the cases were from the Kostelisko (urban) collection, and one was present in Josefov (rural). Due to the infrequency of occurrence, no statistical analyses were completed on this indicator.

6.3 Linear enamel hypoplasia frequency

LEH presence or absence could be observed in 12.3% infant, 39.9% child and 62.7% of adult remains for all three sites. No infants from Kostelisko (urban) had LEH present. The pooled rural sites had a frequency of 24% of infants with LEH occurrence. The children of the pooled rural sites displayed LEH in 25.35% of individuals, while the adults had an occurrence of 17.69%. When all sites were compared there are statistically significant differences in LEH frequency (p=.000). When the rural populations were compared to the urban population the results were significant (p=.000).

Table 6: Frequency of hypoplasia occurrence

			Frequency	Percent
Kostelisko		Absent	126	26.6
		Present	95	20
		Total	221	46.6
	Missing		253	53.4
		Total	474	100
Josefov		Absent	67	33.2
		Present	27	13.4
		Total	94	46.5
	Missing		108	53.5
		Total	202	100
Lahovice		Absent	148	36.7
		Present	38	9.4
		Total	186	46.2
	Missing		217	53.8
		Total	403	100

Table 7: Chi-square results when all sites compared

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	24.189[a]	2	0
Likelihood Ratio	24.55	2	0
Linear-by-Linear Association	23.829	1	0
N of Valid Cases	501		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 30.02.

Table 8: Chi-square results for pooled rural sites against the urban site

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.214[a]	1	0
Continuity Correction[b]	21.313	1	0
Likelihood Ratio	22.194	1	0
Linear-by-Linear Association	22.169	1	0
N of Valid Cases	501		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 70.58.

b. Computed only for a 2x2 table

Table 9: Demographics for urban and rural sites by sex

sex			Absent	Present	Total
Female	site name	urban	56	38	94
		rural	85	25	110
		Total	141	63	204
male	site name	urban	27	31	58
		rural	65	16	81
		Total	92	47	139

6.3.1 By age-at-death. The infant and child frequency of LEH occurrence is not significant. In the adult remains for all three sites the two-tailed chi-square statistic was significant (p=.000). When hypoplasia frequency was tested against age-at-death in each site the results for Kostelisko (urban) and Josefov (rural) were not significant. At Lahovice (rural), the results were significant (p=.021). When the rural populations are pooled the chi-square statistic only shows significance for the adult age group (p=.000).

Table 10: Frequency of LEH occurrence by age for all sites

		Absent	Present	Total
Kostelisko	Infant	0	0	0
	Child	40	23	63
	Adult	84	70	154
	Total	124	93	217
Josefov	Infant	5	0	5
	Child	15	6	21
	Adult	46	21	67
	Total	66	27	93
Lahovice	Infant	14	6	25
	Child	3	4	7
	Adult	131	28	159
	Total	148	38	191

Table 11: Frequency of LEH occurrence by age in urban and rural sites

		Percent
Urban	Infant	0.00
	Child	35.50
	Adult	45.45
Rural	Infant	24.00
	Child	25.35
	Adult	17.69

Table 12: Chi-square results for all sites when tested against age

		Value	df	Asymp. Sig. (2-sided)
Kostelisko	Pearson Chi-Square	1.461[a]	1	0.227
	Continuity Correction[b]	1.119	1	0.29
	Likelihood Ratio	1.475	1	0.224
	Linear-by-Linear Association	1.455	1	0.228
	N of Valid Cases	217		
Josefov	Pearson Chi-Square	2.221[c]	2	0.329
	Likelihood Ratio	3.603	2	0.165
	Linear-by-Linear Association	1.409	1	0.235
	N of Valid Cases	93		
Lahovice	Pearson Chi-Square	7.708[d]	2	0.021
	Likelihood Ratio	6.345	2	0.042
	Linear-by-Linear Association	3.334	1	0.068
	N of Valid Cases	186		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 27.00.

b. Computed only for a 2x2 table

c. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 1.45.

d. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 1.43.

Table 13: Chi-square results when age-at-death is compared for all three sites

age-at-death		Value	df	Asymp. Sig. (2-sided)
Infant	Pearson Chi-Square	1.974[c]	1	0.16
	Continuity Correction[b]	0.672	1	0.412
	Likelihood Ratio	3.119	1	0.077
	Linear-by-Linear Association	1.895	1	0.169
	N of Valid Cases	25		
Child	Pearson Chi-Square	1.860[d]	2	0.395
	Likelihood Ratio	1.816	2	0.403
	Linear-by-Linear Association	0.206	1	0.65
	N of Valid Cases	91		
Adult	Pearson Chi-Square	28.199[e]	2	0
	Likelihood Ratio	28.874	2	0
	Linear-by-Linear Association	28.124	1	0
	N of Valid Cases	380		

b. Computed only for a 2x2 table

c. 3 cells (75.0%) have expected count less than 5. The minimum expected count is 1.20.

d. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.54.

e. 0 cells (.0%) have expected count less than 5. The minimum expected count is 20.98.

6.3.2 By sex. The result of the chi-square statistic was not significant between individual sites. When sex was tested for between the urban and rural populations both sexes were significant.

Table 14: Frequency of LEH occurrence by sex for all sites

		Percent
Kostelisko	Female	67.90
	Male	100.00
Josefov	Female	41.70
	Male	70.00
Lahovice	Female	24.60
	Male	16.40

Table 15: Chi-square results for sex between pooled rural and urban sites

sex		Value	df	Asymp. Sig. (2-sided)
Female	Pearson Chi-Square	7.438[c]	1	0.006
	Continuity Correction[b]	6.632	1	0.01
	Likelihood Ratio	7.453	1	0.006
	Linear-by-Linear Association	7.401	1	0.007
	N of Valid Cases	204		
male	Pearson Chi-Square	17.147[d]	1	0
	Continuity Correction[b]	15.674	1	0
	Likelihood Ratio	17.224	1	0
	Linear-by-Linear Association	17.023	1	0
	N of Valid Cases	139		

b. Computed only for a 2x2 table
c. 0 cells (.0%) have expected count less than 5. The minimum expected count is 29.03.
d. 0 cells (.0%) have expected count less than 5. The minimum expected count is 19.61.

6.4 Linear enamel hypoplasia age of occurrence

The results for the regression equation applied to LEH formation age are separated into six subcategories by tooth class. The maxillary teeth are presented before the mandibular teeth.

Table 16: Summary LEH age of occurrence for combined rural and urban sites

	Minimum Age	Maximum Age	Average Age
maxillary canine	1 year 3 months	5 years 2 months	3 years 1 month
maxillary central incisor	11 months	4 years 6 months	2 years 6 months
maxillary lateral incisor	1 year 6 months	4 years 2 months	2 years 10 months
mandibular canine	11 months	5 years 9 months	3 years 9 months
mandibular central incisor	8 months	3 years 4 months	2 years 2 months
mandibular lateral incisor	4 months	3 years 4 months	2 years 4 months

6.4.1 Maxillary canine.

Table 17: Maxillary canine LEH age of occurrence

	Minimum Age	Maximum Age	Average Age
Kostelisko	1 year 3 months	5 years 2 months	3 years 2 months
Josefov	1 year 6 months	5 years 2 months	3 years 1 months
Lahovice	1 year 4 months	4 years 3 months	2 years 11 months

Thirty-nine individuals at Kostelisko (urban) had at least one LEH, compared to 12 and 19 at Josefov (rural) and Lahovice (rural). At Kostelisko 10 individuals had at least two LEH, while at Josefov and Lahovice the numbers were four and seven. Each site had an individual who displayed three LEH on the maxillary canine. No statistical significance was found between sites for this tooth.

6.4.2 Maxillary central incisor.

Table 18: Maxillary central incisor LEH age of occurrence

	Minimum Age	Maximum Age	Average Age
Kostelisko	1 year	4 years 6 months	2 years 6 months
Josefov	11 months	4 years 6 months	2 years 8 months
Lahovice	1 year 6 months	3 years 8 months	2 years 7 months

Thirty-one individuals at Kostelisko (urban) had least one LEH. Eight individuals at Josefov (rural) had at least one LEH and 16 individuals at Lahovice (rural). At Kostelisko nine individuals had at least two LEHs while at Josefov and Lahovice the numbers were four and three. No individuals at Lahovice had a third LEH on this tooth. Only one individual at Kostelisko and at Josefov had a third LEH present. No statistical significance was found for this tooth between sites.

6.4.3 Maxillary lateral incisor.

Table 19: Maxillary lateral incisor LEH age of occurrence

	Minimum Age	Maximum Age	Average Age
Kostelisko	1 year 8 months	4 years 2 months	2 years 11 months
Josefov	1 year 10 months	3 years 8 months	2 years 11 months
Lahovice	1 year 6 months	3 years 4 months	2 years 8 months

Twenty-one, 10 and nine individuals had at least one LEH present at Kostelisko (urban), Josefov (rural) and Lahovice (rural). Three individuals had a second LEH at

Kostelisko, while Josefov and Lahovice each had only one individual. No individuals had more than two LEH on this tooth. No statistical significance was found between sites.

6.4.4 Mandibular canine.

Table 20: Mandibular canine LEH age of occurrence

	Minimum Age	Maximum Age	Average Age
Kostelisko	1 year	5 years 9 months	3 years 10 months
Josefov	1 year 11 months	5 years 4 months	3 years 6 months
Lahovice	11 months	5 years 6 months	3 years 6 months

Kostelisko (urban) had 54 individuals, Josefov (rural) had 15 and Lahovice (rural) had 26 individuals with at least one LEH. The same pattern frequency of LEH continues for individuals with at least two LEH for this tooth. At Kostelisko 26 individuals had at least two LEH. At Josefov and Lahovice the numbers were five and seven respectively. Five individuals at Kostelisko had at least three LEH. Josefov and Lahovice had one and two individuals. This was the only tooth upon which a fourth LEH was present in any collection. Both Kostelisko and Josefov have one individual with a fourth LEH present. No statistical significance was found between sites.

6.4.5 Mandibular central incisor.

Table 21: Mandibular central incisor LEH age of occurrence

	Minimum Age	Maximum Age	Average Age
Kostelisko	8 months	3 years 4 months	2 years 2 moths
Josefov	2 years 5 months	3 years 3 months	2 years 9 months
Lahovice	1 year 6 months	2 years 9 months	2 years

Nineteen individuals at Kostelisko (urban) had at least one LEH, while at Josefov (rural) and Lahovice (rural) the numbers were two and seven individuals. No individuals at Josefov had two LEHs for this tooth. At Kostelisko and Lahovice there were six and three individuals respectively. No individuals at any site had more than two LEHs present. No statistical significance was found between sites.

6.4.6 Mandibular lateral incisor.

Table 22: Mandibular lateral incisor LEH age of occurrence

	Minimum Age	Maximum Age	Average Age
Kostelisko	4 months	3 years 1 month	2 years 5 months
Josefov	2 years 2 months	3 years 4 months	2 years 8 months
Lahovice	1 year 2 months	3 years	2 years 1 month

Kostelisko (urban) has the highest number of individuals with at least one LEH with 28 individuals. Lahovice (rural) had the median number of 10 individuals, and Josefov (rural) had the least with five individuals. The same pattern continued for those individuals with two LEH present. Kostelisko had the most with 11, Lahovice was in the middle with five and Josefov only had one individual. No individuals at any site had a 3rd LEH present. No statistical significance was found between sites

Chapter 7: Discussion

The following discussion will interpret the statistical analyses (chapter 6) with regard to the hypotheses of this thesis. The hypothesis that the rural populations will not differ significant in frequency of non-specific health indicators was supported (Section 5.1). Therefore the rural sites (Josefov and Lahovice) were pooled to create a single rural site to compare against the urban site (Kostelisko). The final two hypotheses are that the urban population (Kostelisko) will differ significantly from the rural populations in frequency of non-specific health indicators and that females will differ significantly from males in all populations in the frequency of nonspecific health indicators. The results of statistical analyses will be discussed by variable in the same order as reported in chapter 6.

7.1 Cribra orbitalia

Cribra orbitalia was present in less than 5% in all samples (see table 2). When comparing the pooled rural and urban sites no statistically significant differences were found between samples. The same result was true when the individual samples were tested by sex. Only when sites were compared by age was there a statistically significant difference for cribra orbitalia incidence. In fact, age was statistically significant for the urban and rural sites (see Table 4). Children would be more susceptible to the most common causes of cribra orbitalia such as anemia and a high parasite load (Kent, 1986). Due to the higher nutritional requirements during growth and development, children are more susceptible to malnourishment (Betsinger, 2007). Furthermore, children are more prone to pathogenic infection due to malnourishment, as their immune system is not fully developed (Betsinger, 2007).

The frequency of cribra orbitalia in Great Moravia in the early medieval period was very consistent among all samples. This consistency likely indicates a dietary deficiency was present in the population. Because Great Moravia was located in a fertile area near the Morava River, the populations practiced intensive agriculture. Herold (2008) states that Slavic populations in the early medieval period likely grew cereals, fruits, vegetables and legumes. They also practiced animal husbandry by raising cows, pigs, goats, sheep, chickens and geese and hunted deer for protein.

The cereals grown included a variety of species such as barley, several strains of wheat, spelt, oats and rye (Pearson, 1997). Pearson (1997) uses historic records of gardens and food tithing in the early medieval period to suggest that there was an abundance of food sources available to individuals of all social statuses in this time. She further states that a diet based on foods that were theoretically available to early medieval populations had adequate levels of carbohydrates, fats and proteins available; however, vitamin C may have been in short supply. Due to the evidence of animal husbandry in Great Moravia it is unlikely that iron deficiency anemia was prevalent in these populations, which agrees with Walker et al. (2009) who also concludes that many cases of cribra orbitalia in European populations may have been caused by scurvy or chronic infections. Unfortunately at this time no information regarding scurvy occurrence is available because it has not yet been accessed for Great Moravian populations.

One dietary deficiency may have actually been an overabundance of fiber in the early medieval diet, which can block the ability of the body to absorb micronutrients (Pearson, 1997). The overabundance of fiber would be particularly damaging to children, pregnant women and the elderly. Herold (2008) used stable isotope analysis to examine differences in diet between males and females in Austrian populations of Avars and Slavs in the early medieval period. The results indicate that women in those populations had less access to proteins such as meat and dairy than males. As noted above (see chapter two) historic records also suggest that populations did not view the nutritional needs of children in order to support growth in the same way modern populations do, as food distribution recommendations indicate very small portions for children (Pearson, 1997). This lack of sufficient nutrition would have been compounded in infants and very young children by insufficient nutrients in breast milk due to the mother not receiving enough protein. Walker et al. (2009) found that cribra orbitalia is most frequently caused by megaloblastic anemia passed from a vitamin B_{12} deficient mother to their infant via breast milk.

The rate of cribra orbitalia is much lower than the frequency reported in other early medieval populations (Slaus, 2008). This low frequency of cribra orbitalia occurrence could be due in part to issues with variable preservation of the remains. Many of the remains were fragmented and unable to be accessed for cribra orbitalia presence due to a lack of the diagnostic areas. Thus, the actual incidence of cribra orbitalia may be underestimated in this sample. Conversely the lower rates may reflect a balanced diet of agriculture in a highly fertile location of Great Moravia, as discussed above. A third and final reason may be that preservation of the skeletal remains in this collection affected the accuracy of assessment for cribra orbitalia. Jacobi and Danforth (2002) found a high level of interobserver agreement on the presence or absence of cribra orbitalia and porotic hyperostosis when the pathology was present. When the lesions were healing the rate of interobserver error increased, and preservation of the remains could greatly influence the results of the scorers in the study (Jacobi and Danforth, 2002). Which means that it is possible that the rate of cribra orbitalia occurrence is higher than reported but was missed due to healed or healing lesions being mistaken for poor preservation. The low frequency of cribra orbitalia occurrence makes it unlikely that some instances of poor preservation were mistaken for healing lesions.

7.2 Porotic hyperostosis

Due to the presence of only three observed cases of porotic hyperostosis, no statistical analyses were performed on this health indicator. The infrequency of porotic hyperostosis in the studied samples could be attributed to a several causes. As porotic hyperostosis shares an etiology with cribra orbitalia, which was present in the populations, the author concludes that anemia was also present in the samples studied. The lack of porotic hyperostosis is in agreement with Walker et al.'s (2009) study of the causes of cribra orbitalia and porotic hyperostosis. He found that both pathologies are more likely to be caused by megaloblastic anemia as stated above than iron-deficiency anemia and that porotic hyperostosis is very infrequent in European populations that do not have a high rate of malarial related genetic anemias. The presence of dairy products and meat from domesticated animals could have provided enough vitamin B12 to prevent most infantile cases of megaloblastic anemia. The preservation of the remains could also be a factor in the low frequency of porotic hyperostosis occurrence in the collections. Many of the remains had experienced heavy weathering and fragmentation, which affected examination of the remains.

7.3 Linear enamel hypoplasia frequency

LEH occurrence was much more variable than cribra orbitalia frequency (see table 5). When all three sites were compared the differences were highly statistically significant (see table 6). These rates of LEH occurrence are much lower than in early medieval Croatia, which represents some of the few samples of early medieval Slavic populations for which a comparison is possible. At sites in Croatia's frequencies ranging 54.1% to 74.8% were reported (Slaus, 2008). When the frequency of LEH presence in the portion of Kostelisko that had diagnostic teeth for assessment is compared to the results of Slaus (2008), the frequencies are much closer to medieval Croatia. Josefov and Lahovice still have a much lower frequency of LEH occurrence than the published article.

When the rural populations were pooled and compared against the urban population statistical significance ($p=.000$) was again found (see table 7). Palubeckaitė et al. (2002) states that the life of peasants in the medieval period may have actually been easier than urban life. Hygiene and sanitation in the medieval period were drastically different than in modern life. Urban populations were subject to much higher disease loads than rural populations. Infectious diseases such as tuberculosis were endemic in medieval Europe. Mikulčice is estimated to have had a population as large as 1,000 to 2,000 people, which is larger than most cities of the time and more comparable to towns in the late medieval period (Hansel, 1969). While the population of the urban center would be able to get food from multiple sources and the population of Kostelisko was wealthy enough to afford luxury items, they could not avoid the disease load caused by having large quantities of people living in a small area.

Statistical differences by sex were also found between the pooled rural and urban samples (see table =14). Slavic society was patriarchal in nature, which has lead some to suggest that selective preference for male children over female may have resulted in males having a larger amount of protein in their diet and greater chance at survival (Palubeckaitė et al., 2002). Historic records and stable isotope analysis also support sex-biased investment of resources in the medieval period (Pearson, 1997; Herold, 2008). However these assumptions are not supported by the current study. As with cribra orbitalia, sex was not a significant factor in LEH occurrence for the individual populations. This lack of association was also found to be true in early medieval Croatia (Slaus, 2008). While it is not statistically significant, females do show a trend of higher rates of LEH than males in all samples (see table 13). In order for LEH to form, an individual has to be under enough stress to impact enamel formation, and later must recover from the stress so that enamel production can return to normal levels.

The adults for both the pooled rural against the urban and for all three combined sites were statically significant. Only Lahovice showed statistically significant interaction between age and population, which may be tied to its demographic variation from the other sites. Kostelisko and Josefov follow a similar trend for demographics (see table 9). Approximately 53% adults comprise both sites, and approximately 1/3 of the total population is children. Josefov does have nearly double the amount of infant remains compared to Kostelisko. Lahovice does not follow this trend. Sixty-one percent of its population is adults and children only comprise 2.7%. The infant proportion of Lahovice is also higher than expected at approximately 1/3 of the total population. Individual site information was examined in this instance in order to better understand the trend observed.

Lahovice exhibits the lowest frequency of LEH occurrence in adults of the three sites, less than half the frequency of Kostelisko. It also had the lowest overall frequency of LEH occurrence. Goodman and Rose (1990) report LEH frequencies in modern populations to be around 10%, and Lahovice was the only site to have comparable frequency of LEH. The other sites compare more closely with Obertová's (2005) study of early medieval Slovakia. In order for the high percentages found at Kostelisko and Josefov stress events such as disease and malnutrition must have been frequent and very severe.

Lahovice is more geographically isolated and not associated with an urban center, such as Mikulčice: as noted previously this would decrease the infectious disease load even more than at Josefov, which is associated with an urban center. This isolation might increase nutritional stress if crop yields varied over time and there was no urban center nearby to obtain supplemental foods. The high infant mortality at this site could indicate greater stress on this population than the other sites. LEH frequency may be lower because the population died before enamel was disrupted.

7.4 Linear enamel hypoplasia formation age

For all teeth except maxillary central incisor, Kostelisko had the broadest age range for LEH formation according to the regression formula (see table 15). In the case of the maxillary central incisor, Josefov had the broadest age range. Lahovice had the narrowest age range for all the maxillary teeth, and Josefov had the narrowest age range for all the mandibular teeth measured. For all teeth except the maxillary central incisor, Josefov and Lahovice had similar age ranges for LEH formation, which may be due to both sites being rural and not under the disease load that an urban population would be subject to. The maxillary central incisor has a similar formation time to all incisors, and therefore should show the same stress events as the other incisors. Polar teeth are more susceptible to hypoplasia formation, as reflected in these findings (Goodman and Armelagos, 1985).

The average age of LEH formation at all sites was between two and three years for all teeth except for the mandibular canine, which averaged an age of three years nine months. Josefov and Lahovice had an average of three years six months for the mandibular canine while Kostelisko averaged three years 10 months. This is the only exception to the average age range lying between two and three years of age. The mandibular canine is also the only tooth to have individuals with four distinct LEH events present. The maxillary canine, and maxillary central incisor had a maximum of three LEH events, while all other tooth classes had a maximum of two LEH events.

The common average age of LEH formation is often related to weaning a child from breast milk and introducing it to solid food. In modern populations, breast-feeding varies in length between 18 months and four years (Hilson, 1979). Hilson (1979) suggests that some societies may breast feed for longer periods of time as a form of contraception, or as a way to slowly introduce the child to solid food. While making the transition to food sources the child would be particularly susceptible to disease and food borne pathogens. According Palubeckaitė et al. (2002) weaning in the medieval period would have taken place before a child reached four years of age, which fits the results found for all teeth except the mandibular canine. This average age of formation is similar to those reported in Obertová (2005) study of LEH formation age in early medieval Slovakia.

The mandibular canine stands out from all other tooth classes for all sites. It is the only tooth, which had similar results to published studies on other agricultural and medieval populations (Goodman et al., 1984; Palubeckaitė et al., 2002). Continued disease and malnutrition likely contributed to the higher average age of LEH formation on this tooth. As the average age is between three and a half and four years, the incisors would be nearly finished forming and likely ready to erupt. This could be why they were not as affected by the stress events which at that age.

Both canines have LEH events occurring after five years of age, however, the mandibular canine is the only one that has a range from under one year of age to nearly six years of age. The maxillary canine does not start enamel formation until slightly after the mandibular canine and therefore does not have as long a range of time to record enamel disruptions, which could explain why this is the only anterior tooth with four LEH events. As this tooth begins development sooner, it is exposed to more stress events that can effect enamel formation.

Kostelisko may have the broadest age range of enamel defects due to its wealth. Aristocracy in early medieval Lithuania and Denmark had a younger age of onset of LEH events, which Palubeckaitė et al. (2002) suggest may be due to the children of wealthy families being able to afford more resources. The link between wealth and health is not conclusive, but wealthy individuals are less likely to go hungry than those unable to afford food. Kostelisko was not an aristocratic suburb of Mikulčice, but it was wealthy enough to be comparable. Mikulčice was located near very profitable silver mines that brought considerable wealth into the city and attracted merchants from all over Europe. This brought an influx of not only luxury goods and food items, but also infectious diseases (Curta, 2005).

Chapter 8: Conclusion

Great Moravia became the first Slavic society to reach a state level during a time of great political upheaval in Europe. Charlemagne died in 814 CE leaving his empire that spanned much of Europe to be split between his sons (Sypeck, 2007). The Frankish empire would never again reach the size it had previously, but it was still a significant political factor in early medieval Europe. Located between the Frankish, and Byzantine Empires and the Roman Papacy (see Figure 1) Great Moravia was influenced by three. Between 822 and 906 CE Great Moravia grew in size until it covered of the modern Czech Republic, and parts of Slovakia Austria (see Figure 2).

During the early medieval period the political powers in Europe were in transition, and so too were the ways people live. Christianity was becoming the dominant religion on the continent due in part to Charlemagne's conquests (Sypeck, 2007). As Christianity spread, it changed the way that people lived. Saints Cyril and Methodius travelled to Great Moravia to spread Christianity and to translate the bible into the Slavic basis, which provided the basis for the modern Cyrillic alphabet (Dvornik, 1964).

Churches were built, and burial goods were no longer an acceptable way to display social status. Instead burial proximity to a church became more important (Barford, 2001; Vélèminsky and Poláček, 2008). Perhaps in part due to the political and social change they were experiencing, people began to change the way they lived. Towns and urban centers began to develop, allowing for further changes to be made to society as social stratification increased. During this time period social status was still fluid, and not as rigid as it became in the late medieval period (Mitteis, 1975; Schulze, 1996).

The earliest origin of towns is debated among scholars (see section 3.5) The reasons for why towns developed is also a matter of debate. Mikulčice is considered one of the earliest towns to have a population over 1,000 individuals, and was comparable in size with those of the later medieval period (Hansel, 1969; Vélèminsky and Poláček, 2008). With this change in settlement pattern the lifestyles of the inhabitants of urban and rural towns changed. Craft specialization, which was already present in Slavic society, continued to evolve and new crafts developed.

This thesis examines whether the social and political changes society underwent in the early medieval period had an impact on the health of the inhabitants of Great Moravia. Non-specific stress indicators were accessed in order to provide evidence about the health of the populations (chapter 2). Three collections representing an urban center (Kostelisko), and two rural populations (Josefov and Lahovice) were examined in this study.

Several hypotheses were tested in this thesis. Firstly, rural populations have significant differences in non-specific health indicators. Secondly, urban and pooled rural populations differ significantly. Thirdly and last, females would differ significantly in non-specific health indicators from males.

The results of this study support the first hypothesis. Josefov and Lahovice are not significantly different, and therefore were later pooled to increase sample size in statistical analysis. Demographically Lahovice appeared to have a much greater proportion of the population that died as infants, and a much smaller proportion of the population that died as children when compared to Josefov and Kostelisko. Issues with preservation could have skewed the results and not reflect an actual difference in demography. Lahovice is not located near Josefov and Kostelisko, and therefore the soil acidity could be markedly different, which could influence skeletal preservation. More likely Lahovice did have a higher rate of infant mortality than the other sites.

Lahovice and Josefov were not expected to have significant differences due to despite differences in the average social status of the inhabitants. Lahovice was not associated with Great Moravia or any urban center in the early medieval period (Likovsky et al., 2005). Josefov is located eight kilometers from Mikulčice, and therefore was in frequent contact with an urban population (Vélèminsky and Poláček, 2008). Grave goods found at Josefov indicate a fairly wealthy population (Stranska et al., 2002). No information is available about grave goods at Lahovice, and therefore a comparison of social status based on this criterion could not be made. Lahovice's isolation from urban centers and trading markets may have resulted in limited access to foods beyond agricultural production. While Lahovice's limited access to non-agricultural foods may be partially true, as evidenced by the apparently higher infant mortality rate, but it is not statistically significant.

Rural populations have lower levels of infectious disease than urban populations (Larsen, 1997). The lower disease load may be true, but urban populations have access to a greater variety of food sources and are less likely to suffer from malnutrition (Palubeckaitė et al., 2002). The difference this makes in over health as evidenced by occurrence of cribra orbitalia, porotic hyperostosis and LEH was tested in the second hypothesis. This hypothesis was only partially supported. Cribra orbitalia frequencies were not significantly different between urban and rural populations; in fact, they were very consistent in the populations studied. Porotic hyperostosis was only present in three individuals, and therefore could not be statistically measured for this study. The frequency of LEH was statistically significant for several criteria between urban and rural populations.

The consistency of cribra orbitalia in all sites indicates that anemia was not more frequent in the rural populations than the urban. Low levels of dietary deficiency are present in all populations, and not dependent on social status in the early medieval period. Cribra orbitalia presence was statistically significant among age groups, with high frequency in children. As children need more nutrients in order to support growth and development of their bodies, this result is not surprising.

LEH frequency was statistically significant in multiple tests. Rural and urban populations showed significant differences in LEH frequency. Kostelisko had the highest frequency of enamel defects, which may be related to the higher disease load in urban populations. Age played a significant role in the difference in LEH frequencies between the urban and rural populations. This is also seen in Lahovice when the sites were looked at individually. This may be due to the higher rate of infant mortality rate found in that site.

The third hypothesis was again only partially supported. Sex differences were only present when the pooled rural sites were tested against the urban site for LEH frequency. Due to the patriarchal structure of Slavic society, male children may have been more valued than female children for their ability to assist the family financially. Slavic societies are reported to have practiced sex-biased child investment strategies with more resources being invested in male children (Guatelli-Steinberg and Lukacs, 1999; Ortner, 2003). Stable isotope analysis has found that males had greater access to protein than females (Herold, 2008). This could result in female children having more frequent and severe enamel defects due to higher levels of malnutrition and disease. However these practices were not found to be present in the present study. In fact females were found to have a lesser incidence of LEH occurrence. Thus no evidence to support male preference involved in child rearing is present.

The results of the regression analysis for LEH age of formation suggest that disease load had the greatest effect on enamel production. The majority of LEH formation was during the age range when children were weaned from breast milk and introduced to solid foods that could contain pathogens. The hypoplasia formation ages indicate that prolonged exposure to disease had a greater influence on enamel defect formation than malnutrition. This is supported by the consistency of cribra orbitalia frequencies in all populations. Dietary deficiency does not appear to have been significantly different in urban and rural populations, however differences were present.

During the early medieval period urban centers were just starting to develop in Europe (see section 3.5). The results of this thesis indicate that the early urban centers such as Mikulčice were not yet very differentiated from neighboring rural populations. These similarities may be explained in part due to the association between Josefov and Kostelisko. The demographics of Josefov and Kostelisko are similar, as is the infant mortality rate. Lahovice, which was not located near an urban center, displayed the highest infant mortality rate of the three populations. The demographics of Lahovice showed a different pattern of mortality than Josefov and Kostelisko.

The population of Kostelisko was wealthier than those of Josefov or Lahovice, and therefore able to afford access to more food resources as well as luxury items. They were also subject to a higher level of infectious disease, which appears to have had a significant impact on the development of enamel defects in comparison to the rural populations. Dietary deficiency does not appear to have played a significant role in the development of non-specific health indicators for Josefov or Kostelisko, but did influence Lahovice slightly.

Josefov's association with an urban center increased the social status of the inhabitants, and increased the ability of the inhabitants to barter for food supplies they did not produce, which may have buffered them further from malnutrition. The frequent contact would have allowed communicable diseases to spread quickly between the populations. Josefov still had a lower disease load than an urban center, while having the advantage of being associated with it. The inhabitants of Kostelisko were the wealthiest population studied and the only urban one. In addition to higher levels of infectious disease, the population may have been better able to recover from stress events due to the advantages of wealth, as evidenced by the trend of having the broadest range of LEH age formation.

While all lines of evidence did not equally support the hypotheses tested in this thesis, each hypothesis had differing levels of support. The hypothesis that the rural populations of Josefov and Lahovice would not differ significantly was supported. The hypothesis that the urban and pooled rural populations would differ significantly was supported by LEH occurrence, but not the cribra orbitalia. The final hypothesis that males and females in all populations would differ significantly in terms of non-specific health indicators was not supported. However differences between males and females did differ significantly when tested the urban population was tested against the pooled rural populations.

These results have created new questions to be answered and have implications for modern urban development and migration. Further studies should be done on these populations, including an assessment of scurvy rates and specific health indicators. It would be interesting to compare the population at Kostelisko to populations from the other suburbs of Mikulčice, as well as neighboring urban centers.

Perhaps one of the most interesting findings of this thesis is that urban centers in the early medieval period did not differ significantly from nearby rural centers. The differentiation between urban and rural was not as distinct in this time as they are in the modern period. However this may correspond well with the conditions in developing nations. In these conditions urban migration does not appear to have a negative or positive impact on overall health. The urban populations were slightly buffered from malnutrition, but also had a higher disease load. The similarity between Kostelisko and Josefov indicate that the overall health and lifestyle of urban populations and nearby rural centers is very similar. The differences between Lahovice and Kostelisko may indicate that the further a rural site is from an urban center the greater the differences in health become.

Further study needs to be done on this subject. An increase in sample size and collections would help to better define whether the limited samples had an impact on the results of this thesis. With further study, the effect that urban development and migration had on the health of the inhabitants of Great Moravia and the early medieval period can be better understood. A better understanding of urban migration in this time period could lead to a more accurate understanding of how urban migration in the development world will affect the health of its citizens.

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