Paleoepidemiology of Infectious Disease in the Dickson Mounds Population

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The major focus of paleopathology has been the delimiting of disease in time and space. Information about the history of specific diseases is the objective of many of these studies. While the chronological and geographical dimensions of paleopathology contribute significantly to our knowledge of disease, there are limits to this approach, which often fails to consider the interaction of biology and culture in the diseases of prehistoric populations.

The biocultural approach in paleopathology attempts to define ecological factors in the adaptation of prehistoric populations to their environment which inhibit or promote the disease process. This ecological analysis has been aided by a paleoepidemiological perspective on the interaction of three variables—host, insult, and the environment. The reconstruction of ecological variables in paleoepidemiological studies has provided paleopathology with one of its most important tools.

Roney,[1] in a short but important article that discusses the paleoepidemiological approach to the study of disease, suggests three phases in this type of study:

1) archaeological investigation,
2) study of the skeletal remains, and
3) statistical analysis: relationships between host factors, the disease (insult), and the environment.

It is often difficult to describe the host factors in prehistoric populations, although features such as morphology, age, and sex can be determined. Similarly, the factors which cause disease can be inferred in many instances. Finally, the paleoepidemiologist should delineate the environmental variables so important in the disease process as well as focus on cultural and biological elements which are likely to increase or reduce the potential for disease.

The Dickson Mounds Population offers a unique opportunity to study the adaptation of a prehistoric population by applying the paleoepidemiological approach. The skeletal material represents

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three cultural traditions, that is, the Late Woodland, the Mississippian Acculturated Late Woodland, and the Middle Mississippian, which reflect significant temporal changes in the nature of the cultural-ecological relationships of the population. As a result, these archaeological samples provide adequate skeletal material and cultural-ecological data to apply to our model.

Based upon some of these temporal changes, we have hypothesized that alterations in the cultural-ecological adaptations of a population in the form of: a) a change in subsistence patterns with greater reliance on agriculture; b) an increase in population density and settlement; and c) an extension of trade networks will be reflected in the biological characteristics of that population in the form of increased frequency in infectious lesions and in the rate of mortality.

Archaeology at Dickson Mounds

The skeletal samples used in this analysis are from the Dickson Mounds. The site, which consists of both burial and habitation areas, is located near the confluence of the Illinois and Spoon Rivers, 4.8 km southeast of Lewistown, Illinois. The environment is composed of four zones: a wet flood plain, talus slope forest, highland forest, and a plains-prairie area. The faunal and floral assemblages and their potential for aboriginal exploitation have been described by Harn.[2]

While we can distinguish three cultural traditions associated with the Dickson Mounds, we will combine skeletal samples of the Late Woodland and the Mississippian Acculturated Late Woodland for the purpose of this study. During the time period between AD 950 to AD 1050, the Dickson site was occupied by an indigenous Late Woodland population. The Late Woodland population is defined as a relatively small group (75-125) of people who constructed temporary seasonal campsites near the confluence of the Illinois and Spoon Rivers. Their subsistence economy was directed toward the intensive utilization of a broad range of flora and fauna. During this same time period, the Middle Mississippian culture was developing at Cahokia in the American Bottoms, 180 km to the south near what is now East St. Louis, Illinois.

The Late Woodland culture at Dickson Mounds represents a population which was to come under the influence of the Middle Mississippian culture. The cultural manifestation of this influence is termed the Mississippian Acculturated Late Woodland (dated about AD 1050-AD 1200).[2] A representative of this adaptation is the Eveland site which is located 230 m to the southwest of the Dickson Mounds burial complex.

The Eveland site, which covers about 2 hectares, was occupied by a permanently settled population estimated to average about 400-500 individuals. During this period of occupation, a gradual alteration in subsistence techniques occurred; hunting-and-gathering was supplemented by some maize cultivation. Toward the end of this period (AD 1200), items begin to appear in village refuse and as grave offerings which suggest the beginnings of long distance trade.[3]

The Middle Mississippian at Dickson Mounds represents the culmination of trends toward increased maize cultivation, increased population density and settlement, and participation in Mississippian trade networks. The Myer/Dickson site (AD 1200-AD 1300) is an agricultural hamlet of 3-4 hectares in extent. The houses are arranged in rows about an open plaza. Harn[2] estimates the population to range between 150 and 250 individuals. The Myer/Dickson site along with six other hamlets and 31 camps are associated with the Larson ceremonial center, 11 km to the southeast.

Larson consists of 8 hectares of concentrated, and 40 hectares of dispersed, occupation debris scattered around a mound-plaza complex. A palisade encloses the mound, plaza, and 6 hectares of settlement. Harn[4] estimates a maximum of 234 contemporaneous structures in the primary habitation area, which suggests a population of between 900 and 1400 individuals. The Larson community is typical of the complex Mississippian socio-political organization. Quantities of foreign-made items in village debris and cemeteries indicate participation in extensive trade networks. The palisade reflects warfare and the extension of competition for agricultural land outside the American Bottoms.

The subsistence pattern of the Middle Mississippian is different from the preceding Mississippian Acculturated Late Woodland. Because quantitative archaeological data are not yet available, the quality of the Mississippian diet at Dickson Mounds must be reconstructed by inference. The larger population size would increase the effort required to maintain the previous per capita consumption of wild flora and fauna. This dietary deficit is compensated for by increasing the utilization of maize. Although this increase in maize and decrease in animal protein con-

sumption may not appear to be quantitatively significant in the archaeological data, there are mitigating cultural factors. Larson[5] suggests that Mississippian sites (such as the Larson site) were fortified to protect limited agricultural land. Any agricultural crop achieving this importance assumes a certain cultural value which requires its consumption by the infirm and the young.[6] Cook[7] substantiates this premise by reporting that 95% of historic American Indian societies practicing maize agriculture used maize as the exclusive weanling diet. Thus, despite low per capita consumption of maize, its importance in the weaning and convalescent diet could have made protein malnutrition (generated by a decrease in the consumption of animal products and an increase in the use of high carbohydrate/low protein maize) a serious health problem.

Such a subsistence base is an important variable in the evaluation of the general level of health of the population; the large population increase (ten times that of the Late Woodland and twice that of the Mississippian Acculturated Late Woodland) is also an additional consideration in an assessment of the cultural-ecological context of the two Dickson Mounds subpopulations.

Materials and Methods

Of the 595 burials which have been excavated from the Dickson Mounds site during the 1966 and 1967 field seasons, 96% (572) have been examined in our analysis. Because of their fragmentary condition, lack of cultural and/or burial mound affiliation, or because of a lack of age and/or sex data, 4% (23) of the burials have been omitted.

The skeletal materials which we have included consist of those burials which could be categorized by age and sex, assigned to a cultural group, and for which observations on skeletal and dental pathology could be made.[8] The final study samples are described in Table 1.

The diagnosis of skeletal pathology has been made on the basis of gross macroscopic examination of each burial. The paleoepidemiological analysis will focus upon the frequency of occurrence of infectious disease. The infectious diseases which have been diagnosed on the skeletal material from Dickson Mounds include periostitis and osteomyelitis (both suppurative and nonsuppurative). Although separate observations have been made on both the periostitis and on the osteomyelitis, frequencies for the two diseases have been combined.

Results

There are several factors favoring the analysis of infectious disease, the first being that it should reflect variations in the cultural-ecological context of the host population. Second, both periostitis and osteomyelitis leave their imprint on bones and can therefore be readily observed and recorded in a skeletal population. Third, the serious nature of these infectious diseases can easily influence variables such as the rate of mortality and life expectancy.

The frequency of infectious lesions of bone doubles from the combined Late Woodland and Mississippian Acculturated Late Woodland period to the Middle Mississippian period. Based on the entire population (ages 0 to 59.9 inclusive), the Middle Mississippians have a frequency of infectious disease of 67% (149), while the Mississippian Acculturated Late Woodland combined has a frequency of 31% (108). This pattern (summarized in Table 2) is also characteristic of both the subadult (those individuals deter-

TABLE 1
The Distribution of Burials by Age, Sex, and Culture

		SUBADULTS		ADULTS		ADULT MALES		ADULT FEMALES	
CULTURE	N	N	%	N	%	N	%	N	%
*LW-/MALW	351	125	36	226	64	116	51	110	49
**MM	221	110	50	111	50	50	45	61	55
TOTAL	572	235	41	337	59	166	49	171	51

N = Number
*LW + MALW = Late Woodland and Mississippian Aculturated Late Woodland
**MM = Middle Mississippian
Note: The category subadult includes all those individuals who have been determined to be under the age of 15 years. The category of adult includes all of those individuals who have been determined to be over the age of 15 years. All percentages have been rounded off to the nearest whole number.

TABLE 2
Summary Figures for the Frequency of Occurrence of Infectious Disease

AGE	NUMBER	NUMBER WITH INFECTION	%
0-59.9 Years*			
LW + MALW	351	108	31
MM	221	149	67%
0-14.9 Years*			
LW + MALW	125	34	27
MM	110	74	67
15-59.9 Years*			
LW + MALW	226	74	33
MM	111	75	68
15-59.9 Years Females			
LW + MALW	110	35	32
MM	61	43	71
15-59.9 Years Males			
LW + MALW	116	39	34
MM	50	32	64

* These frequencies include the combined Male and Female totals

LW + MALW = Late Woodland and Mississippian Acculturated Late Woodland Combined.

MM = Middle Mississippian

Note: All percentages have been rounded off to the nearest whole number.

mined to have been under 15 years of age) and the adult segments of the population. The difference in infectious pathology between Middle Mississippian and Mississippian Acculturated Late Woodland combined is significant ($p < .05$) as are the differences in the frequencies between cultures in the subadults, adult males, and adult females. In summary, the Mississippians have higher frequencies of infectious disease for both age segments and both sexes. The differences between subadults and adults, or between males and females within samples were not significant in either the Mississippian Acculturated Late Woodland combined or the Middle Mississippian subpopulations.

The higher frequency of infection in the Middle Mississippian sample suggests a difference in the severity and age of onset of infectious lesions. Severity can be determined by comparing the extent of involvement of the various bones of the skeleton or by selecting one bone for intensive analysis. We chose the latter approach with an analysis of infectious involvement of the tibia. The tibia was selected for several reasons: a) it is usually the best preserved of all the long bones; b) it has a broad periosteal surface which facilitates observation; and c) it has the highest prevalence of infectious disease for the study populations from the Dickson Mounds.

The stages of severity of the tibial infection are determined on the basis of a) the extent of involvement of the periosteal surface; b) the nature of tissue destruction (whether pitted, ridged, scarred, or showing sinus tracks); and c) the amount of destruction of bony tissue. Using these criteria of severity, we have identified three stages of the tibial infection: a) slight, b) moderate, and c) severe.

Analysis of infectious lesions of the tibia indicates more frequent and more severe infections in the Middle Mississippian sample (Table 3). Of the 353 tibiae from the Mississippian Acculturated Late Woodland combined, 26% (90) are found with some form of infectious lesion, of which 62% (56) were classified as slight, 30% (27) as moderate, and 8% (7) as severe. Of the 194 tibiae from the Middle Mississippian, 84% (163) show signs of infection; 28% (45) being classified as slight, 49% (80) as moderate, and 23% (38) as severe. The differences between these two populations are significant ($p < .05$). The Middle Mississippians have a higher frequency of tibial infection and a higher frequency of moderate and severe cases.

The age of onset of tibial infection also reflects

TABLE 3
Frequency of Infectious Lesions of the Tibia

	N	INFECTED	%
LW + MALW	353	90	26
MM	194	163	84

Severity of Tibial Involvement

	N	SLIGHT	MODERATE	SEVERE
LW + MALW	90	56 (62%)	27 (30%)	7 (8%)
MM	163	45 (28%)	80 (49%)	38 (23%)

N = Number

LW + MALW = Late Woodland and Mississippian Acculturated Late Woodland combined.

MM = Middle Mississippian

Note: All percentages have been rounded off to the nearest whole number.

the pattern of involvement discussed in the preceding paragraph. The Middle Mississippians show an earlier and more severe onset in young adults when compared to the Mississippian Acculturated Late Woodland combined group. In the combined Late Woodland and Mississippian Acculturated Late Woodland sample of young adults between 15 and 25 years of age, 75% (21) show slight involvement; 18% (5) have moderate infection; and 7% (2) have severe lesions (Table 4). In the Middle Mississippian sample, 30% (10) were classified as slight, 49% (16) as moderate, and 21% (7) as severe. In summary, our analysis indicates that the people of the Middle Mississippian culture had a higher frequency of infectious diseases, contracted the infection at a younger age, and were more severely infected than the people of the combined Mississippian Acculturated Late Woodland.

The various stages of severity of tibial infection and the overall health of an individual cannot be exactly equated; however, infectious lesions which produce the extensive osteological damage noted in the severe stages of involvement in this study must certainly have taxed the body's defensive system and lowered the individual's chances of survival. Although not clearly understood at this point, the relationship between survival probability and the stages of severity of the tibial infection can be inferred. For example, the mean age* at death for the adults (aged over 20 years) of the Mississippian Acculturated Late Woodland is 39.5 years; however, the mean age at death for the adults who had a slight tibial infection is 37 years and for those with a severe infection is 35.1 years. A similar trend is also noted among the adults of the Middle Mississippian: the mean age at death is 33.5 years for all adults, and 29.3 for adults with a severe tibial infection.

These findings suggest that tibial infections may have affected the survival chances of those individuals with these lesions. In general, the mean age at death for those infected is lower than the mean age at death for the rest of the population. Those with severe disease also appear to have died at a younger age than those with slight infections.

These relationships of infection to mortality suggest that the increase in infection could have been one factor affecting the population's mortality profile. Composite life tables were constructed to aid in the analysis of differences in mortality (Tables 5 and 6). The d_x column of the life tables represents the age-specific rate of mortality. If the d_x columns of the two life tables are compared, it is apparent that the

TABLE 4
Frequency of Infectious Lesions of the Tibia, Young Adults (15-25 Years)

	N	INFECTED	%
LW + MALW	114	28	25
MM	43	33	77

Severity of Tibial Involvement

	N	SLIGHT	MODERATE	SEVERE
LW + MALW	28	21 (75%)	5 (18%)	2 (7%)
MM	33	10 (30%)	16 (49%)	7 (21%)

N = Number
LW + MALW = Late Woodland and Mississippian Acculturated Late Woodland combined.
MM = Middle Mississippian
Note: All percentages have been rounded off to the nearest whole number.

TABLE 5
Life Table For the Late Woodland and the Mississippian Acculturated Late Woodland for the Ages 0-60 Years

X	d'x	dx	lx	qx	Lx	Ex
0	45	128	1000	128	936	26
1	28	80(21)	872	92	832	29
2	18	51(26)	792	64	2299.5	30
5	21	60(32)	741	81	3555.0	29
10	13	37(36)	681	54	3312.5	27
15	26	74(43)	644	115	3035.0	23
20	49	140(57)	570	246	5000	21
30	33	94(66)	430	219	3830	16
40	70	199(86)	336	592	2365	10
50	48	137(100)	137	1000	685	5
TOTAL	351	1000	0			

Note: The d_x values appear in parentheses represent the cumulative frequency of mortality. All percentages have been rounded off to the nearest whole number.

* The mean age is arrived at through the following process: Using skeletal aging techniques, we assigned each skeleton a biological age. Using these biological ages, we established age classes. By summing the total of biological ages in each age class and dividing that total by the number of individuals in that age class, we obtained the mean number of years lived by individuals in that age class. By following the same procedure for each adult age class and summing the totals and dividing by the number of adults, we obtained the mean number of years lived by adults. This procedure was carried out for the entire population, then the individuals with infectious lesions were separated out, and the process was repeated.

TABLE 6
Life Table for the Middle Mississippian for the Ages 0-60 Years

X	$d'\chi$	$d\chi$	$l\chi$	$q\chi$	$L\chi$	$E\chi$
0	48	217	1000	217	891.5	19
1	19	86(30)	783	110	740	23
2	16	72(38)	697	103	1983	24
5	17	77(45)	625	123	2932.5	24
10	10	45(50)	548	82	2627.5	22
15	23	104(60)	503	207	2255	18
20	24	109(71)	399	273	3445	18
30	27	122(83)	290	421	2290	13
40	25	114(96)	168	678	1110	8
50	12	54(100)	54	1000	270	5
TOTAL	221	1000	0			

Note: The $d\chi$ values which appear in parentheses represent the cumulative frequency of mortality. All percentages have been rounded off to the nearest whole number.

Middle Mississippians experienced higher mortality rates in the age classes between 0 and 20 years, especially in infant mortality in the Middle Mississippian sample. In the age class 0 to 0.9 years, 22% (48) of the Middle Mississippian newborns died, while only 13% (45) of the Mississippian Acculturated Late Woodland combined newborns died. The results of Kolmogrov-Smirnov tests demonstrate that for the three comparisons which have been noted, the Middle Mississippians had significantly higher mortality frequencies than the Mississippian Acculturated Late Woodland combined ($p < .05$).

Between the ages of 20 and 60 years, the age-specific frequencies of mortality are lower for the Mississippian Acculturated Late Woodland combined group than they are for the Middle Mississippians. These findings suggest that people of the Middle Mississippian culture were dying at younger ages and at higher frequencies than the people of the Mississippian Acculturated Late Woodland combined. For example, by the age of 19.9 years, 60% (133) of the Middle Mississippians have died, while only 43% (151) of the other group have died. Similarly, by the age of 49.9, 95% (209) of the Middle Mississippians have died, but only 86% (303) of the Mississippian Acculturated Late Woodland combined group have died.

Since life expectancy is a result of the mortality experience, the mortality differences noted should be reflected in life expectancy. The Middle Mississippian subpopulation has a lower life expectancy for every age class. For example, life expectancy at birth is 26 years for those in the Mississippian Acculturated Late Woodland combined group and 18 years for those in the Middle Mississippian sample. The differences are greater during the childhood years but narrow in the subadult and adult phases of development.

Conclusions

In this paper we have attempted to demonstrate how a hypothesis derived from archaeological data can be independently tested using skeletal materials. We have proposed a hypothesis which suggests that the transition from the Late Woodland-Mississippian Acculturated Late Woodland to the Middle Mississippian resulted in an alteration in the adaptive systems of the two groups in the form of: a) an increased reliance upon maize agriculture; b) an increase in population density and settlement; and c) an extension of trade networks and social contacts. We have also suggested that the alterations which occurred in the adaptive systems of the two study samples may have influenced some of the biological characteristics of the population.

An alteration in the subsistence base may produce periods of nutritional inadequacy which, in turn, can influence the general level of health of a population by decreasing its resistance to disease. An extension of trade networks and social contacts can be the means of introducing new pathogens and/or vectors into a population thereby increasing the frequency of diseases (especially infectious disease). An increase in settlement of a population would put the host and pathogen into a permanent relationship which might result in the generation of chronic types of conditions. The increase in population density can serve two functions. First, it increases the number of potential hosts and the population can become a reservoir for infectious pathogens. Second, the increase in population density results in the quick and efficient transmission of disease within a population. Armelagos and Dewey[9] have discussed how changes in the cultural adaptive systems of human populations have influenced the patterning and frequency of disease. In general, the results of their study illustrate that an extension of trade networks and an increase in population density and settlement will increase the frequency of infectious disease within a population. In addition, Scrimshaw[10] has outlined the nature of the "synergistic" interaction of nutrition and infectious disease and has demonstrated how this

interaction can increase the frequency of both disease and mortality.

The Middle Mississippians from the Dickson Mounds experienced alterations in the nature of their cultural adaptive system. The characteristics of the nutritional resources of the Middle Mississippians and the frequency of infectious disease conform to the pattern suggested by Scrimshaw.

The difference in the frequency of infectious pathology between the Mississippian Acculturated Late Woodland and the Middle Mississippians is similar to the pattern observed in other pathological conditions. Lallo and co-workers[11] in an analysis of porotic hyperostosis, a condition related to nutritional stress, demonstrate its increase in the Middle Mississippian sample. Working with a subadult segment of the sample (age 0-15 years), we noted that the rate of pathology increases from 26% (137) in the Mississippian Acculturated Late Woodland combined to 52% (101) in the Middle Mississippian. The porotic hyperostosis was more severe in the later Middle Mississippian groups.

In summary, we have demonstrated that in all age and sex classes, the Middle Mississippian sample of the Dickson Mounds population has a significantly higher rate of mortality, a higher probability of dying, and a lower life expectancy than the people from the Mississippian Acculturated Late Woodland combined. We have indicated that the Middle Mississippians have a significantly higher frequency of infectious lesions than the Mississippian Acculturated Late Woodland combined sample of the population and that these infections are more serious and have an earlier age of onset.

The study demonstrates the usefulness of employing both skeletal and cultural-archaeological data in an attempt to understand the evolutionary implications of biocultural interaction.

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