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DISEASE AND MORTALITY AT THE ANDERSON VILLAGE SITE[1]

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Abstract. Skeletal remains from the Anderson Village site provided information on mortality patterns in one of Ohio's early American Indian groups. At birth, life expectancy for the Anderson population was approximately 33 years, with a mean age at death of 6.6 years for the sub-adults (<15 years of age), 39 for the adult males, and 38 for the adult females. The highest age specific mortality rate for the sub-adults occurred in the age class 5 to 9.9 years (6.8%), while for the adults it was in the age class 40 to 44.9 years (15.9%). Although there were variations between male and female mortality rates, none of the observed differences were statistically significant. For the subadults, adult males, and adult females, mortality was significantly associated ($P<.001$) with infectious disease with 81.8% of the population displaying some lesions. For sub-adults and adult females, mortality was significantly associated ($P<.001$) with the occurrence of both infectious disease and porotic hyperostosis with 80% of the sub-adults and females displaying both lesions. It appears that infectious disease may have contributed to mortality of sub-adults, males, and females; whereas, the interaction of infectious disease and porotic hyperostosis may have had its most serious impact on sub-adults and females.

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Archaeological and skeletal materials from Anderson were employed to reconstruct and interpret a mortality profile for the population. The research objective was based on the suggestion that the synergistic interaction of infectious disease and sub-optimal nutrition was a precipitating factor in the mortality experiences at Anderson (Lallo *et al* 1978). Scrimshaw (1966) has pointed out that sub-optimal nutrition can influence host resistance to infectious disease, and infectious disease can exacerbate the problems associated with nutritional deficiency.

Among the subadults, the malnutrition and infectious disease syndrome could have precipitated respiratory and gastrointestinal conditions which were characterized by the pneumonia-weaning diarrhea complex. The results of this complex are an increase in nutrient loss, an increase in fluid dehydration, and a general increase in sub-adult mortality. For the adults, the interaction of malnutrition and infectious disease can influence the general level of health and may function as a selective agent in terms of differential mortality (Lallo *et al* 1978). For the Anderson population it can be suggested that the synergistic interaction of malnutrition and infectious disease was an important factor in the mortality experiences of the population.

ARCHAEOLOGY AT ANDERSON

The Anderson Village represented the Anderson Focus of the Anderson Component in the Fort Ancient Aspect (Griffin 1966). The village site was occupied between A.D. 1235 to 1400 (David Brose, personal communication) and was located along the Little Miami River one-fourth mile north of Fort Ancient, and one-fourth mile south of the conjunction of the Little Miami River and Caesar's Creek in South-Central Ohio (Griffin 1966).

The Anderson population represented a permanently settled community which included both habitation and burial areas. The nutritional resources of the population appeared to have been derived pri-

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marily from the cultivation of the till plains and the river valleys. The lithic assemblage included a wide variety of artifacts of flint, bone, antler, and shell. Pottery remains have also been recovered. A description of the general physical environment of the Anderson Village and a detailed discussion of the archaeology have been provided by Griffin (1966).

MATERIALS AND METHODS

The skeletal material used in this study was supplied by the Ohio Historical Society, Division of Archaeology at the Ohio State Museum. The burial inventory produced a total of 82 identifiable human burials and various remains that were too fragmentary to associate with any given burial or to identify as a separate burial. Of the original 82 burials, 14.6% (12) were eliminated from the analysis because of their fragmentary condition and/or their lack of either age or sex data. Age and sex assignments were made for each of the remaining 70 burials. Of the 70 burials, 18.6% (10) were classified as sub-adults (<15 years of age) and 81.4% (57) as adults (>15 years of age). Within the adult segment, 50.9% (29) were identified as males, and 49.1% (28) as females.

Since the analysis of mortality required only age and sex data, all 70 of the burials were included into the study sample. The analysis of pathology, however, required the presence of useable cranial and postcranial remains. Useable remains were defined for the purposes of this analysis as skeletal materials which could be aged, sexed, and observed for pathological lesions. Of the 70 burials which were aged and sexed, only 62.9% (44) could be observed for pathological lesions. The sample of 44 burials constituted 53.7% of the original burials and was comprised of 18.2% (8) subadults and 81.8% (36) adults. In the adult segment, 52.8% (19) were classified as males and 47.2% (17) as females. Since the objective of the present study was to demonstrate that malnutrition and infectious disease were important factors in mortality at Anderson, the analysis was restricted to the sub-sample of 44 burials. This procedure was justified on two bases: 1) chi square results demonstrated that there were no significant differences between the two groups (i.e., N = 70 and N = 44) with respect to the age and sex distribution of the burials; and 2) the results of the Kolmogorov-Smirnov Test (Seigel 1956) indicated that there were no significant differences between the two groups with respect to mortality frequencies. Consequently, it can be suggested that the sub-sample of 44 burials adequately represented the burial population of Anderson. The analysis of populational mortality was based upon the use of the Composite Life Table (Deevey 1947, Quick 1963), and observations for infectious disease and the nutritional disorder were made through a gross macroscopic examination of each burial.

Although criticism has been made concerning the use of life tables (Angel 1969), several investigators have demonstrated their utility as a research tool in paleodemography (Lovejay 1971, Moore *et al* 1975, Weiss 1973). Swedlund and Armelagos (1976) have outlined some of the potential difficulties that may be encountered when applying the Composite Life Table to an archaeological population and have specifically dealt with the problems of infant under-representation and sampling bias. They have noted that infant under-representation only affected the survivorship values of the life table and did not seriously influence the remaining functions. Sampling bias presented a more serious problem, and the authors cautioned that great care should be used when making inter-populational comparisons on the basis of such data. Because the sub-sample of burials (N = 44) from Anderson was small, the analyses and interpretations of this study were limited and confined to an intra-populational level suggesting that mortality frequencies can be interpreted in terms of the interaction of malnutrition and infectious disease.

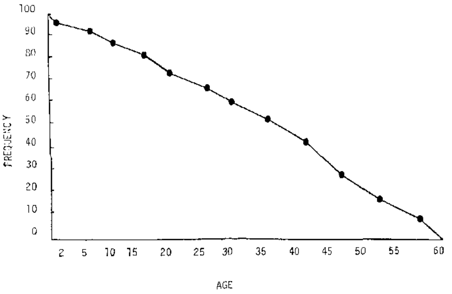

FIGURE 1. Survivorship curve for the Anderson population (N = 44). Based upon the 1_x values in the life table (see table 1).

RESULTS

Paleodemography At Anderson. A Composite Life Table (table 1) and survivorship curve (fig. 1) were constructed for the entire Anderson sub-sample (N = 44) for ages 0 through 59.9 years, inclusive. At birth, life expectancy was 33 years and the probability of dying between birth and 1.9 years of age was .046. For the Anderson population, several age classes appeared to be critical for the people and correspondent to higher mortality rates. For the sub-adults, this age period was between 5 and 9.9 years, during which time 6.8% (3) of the sub-adults had died and for which the probability of dying was .073. For the adults (with the sexes combined), the age intervals 40 to 44.9, 55 to 59.9, and 15 to 19.9 years were critical with mortality rates of 15.9% (7), 13.6% (6), and 11.4% (5) respectively. The probabilities of dying in these age classes were .369, 1.00, and .137 respectively. An interesting perspective was gained on populational mortality by summing the dx values in the life table to obtain the cumulative frequency of mortality. By the age of 15 years, 18.2% of the population had died; by the age of 30, 40.9% had died; and by the age of 45, 72.7% of the Anderson population had died.

TABLE 1

*Composite Life Table For the Anderson Population.**

x	d'_x	d_x	l_x	q_x	L_x	e^o_x
0- 1.9	2	4.55	100.00	.046	195.45	33.0
2- 4.9	1	2.27	95.45	.024	282.95	32.5
5- 9.9	3	6.82	93.18	.073	448.85	30.3
10-14.9	2	4.55	86.36	.053	420.43	27.5
15-19.9**	5	11.36	81.81	.137	380.65	23.9
20-24.9	2	4.55	70.45	.065	340.88	22.3
25-29.9	3	6.82	65.90	.104	312.45	18.7
30-34.9	3	6.83	59.08	.115	278.35	15.6
35-39.9	4	9.08	52.26	.174	238.60	12.3
40-44.9	7	15.91	43.18	.369	176.13	9.3
45-49.9	4	9.08	27.27	.333	113.65	8.3
50-54.9	2	4.55	18.19	.250	79.58	6.3
55-59.9	6	13.64	13.64	1.000	34.10	2.5
Total	44	100.00	—	—	—	—

* x = The age class based upon skeletal age.
d'_x = The actual number of burials in each age class x.
d_x = The age specific mortality rate.
l_x = The survivorship expressed as a percentage of the total population.
q_x = The probability of dying in age class x.
L_x = The total number of years lived by the individuals in each age class x.
e^o_x = The life expectancy expressed in number of years remaining to be lived.
**Age classes between 15 and 59.9 years contain the combined male and female totals.

Subadult Mortality At Anderson. A Composite Life Table was prepared for the sub-adults (N = 8) in an attempt to examine sub-adult mortality independent from adult mortality functions (table 2A). At birth, life expectancy for the sub-adults was 6.6 years, and the probability of dying between birth and 1.9 years of age was .250. The age specific mortality rates indicated that 37.5% (3) had died in the age class 5 to 9.9 years. The probability of dying in this age class was also high (.600) and suggested that this age class was a critical period during the life of a sub-adult from Anderson. By surviving this age class, the sub-adults could expect to live an additional 4.5 years or until the age of 14.5 years. The cumulative frequency of mortality demonstrated that by age 9.9 years, 75.0% (6) of the sub-adults had died.

Adult Male And Female Mortality. A Composite Life Table was constructed for the adult males (table 2B) and for the adult females (table 2C) that showed that the life expectancy for a male at the age of 15 was an additional 24 years, or until the age of 39.0 years while females who had obtained the age of 15 years could expect to live an additional 23.7 years, or until the age of 38.7 years. Age specific mortality rates displayed considerable variation for both the males and females. Males reached a peak in mortality during the years between 40 and 44.9 (21.1%), while females showed three age classes with high mortality including 15 to 19.9 years (17.7%), 40 to 44.9 (17.7%), and 55 to 59.9 years (17.7%). For both the males and females, the probability of dying was high in those age classes with high mortality rates. The cumulative frequencies of mortality showed little variation between males and females. For example, by the age of 30, 26.3% (5) of the males and 29.4% (5) of the females had died. By the age of 49 years, 78.9% (15) of the adult males and 76.5% (13) of the adult females had died.

Although there appeared to be small differences between male and female mortality functions, none of the observed differences were statistically significant. The Kolmogrov-Smirnov Test demonstrated that male and female mortality was not significantly different. It should be noted that sample size for the various age classes were often small and that in several age classes only a single burial was present. The existence of sampling bias under these conditions posed serious problems, and it was difficult to determine if the observed mortality frequencies reflected biological reality, or if they reflected sampling bias. In an attempt to control this potential problem, the study sample was expanded to include all 70 of the individuals for whom age and sex data were available. Four Composite Life Tables were constructed for this sample and included a life table for the entire sample (N = 70), one for the sub-adults (N = 13), and one each for the adult males (N = 29) and females (N = 28). The results of the Kolmogrov-Smirnov Test demonstrated that there were no significant differences in mortality between the various segments of the subsample of 44, and the sample of 70 burials ($P < .05$). No significant differences be-

TABLE 2

*A. Life Table For The Sub-Adults Of Anderson.**

x	d'_x	d_x	l_x	q_x	L_x	e^o_x
0– 1.9	2	25.00	100.00	.250	175.00	6.6
2– 4.9	1	12.50	75.00	.167	206.25	6.5
5– 9.9	3	37.50	62.50	.600	218.75	4.5
10–14.9	2	25.00	25.00	1.000	62.50	2.5
Total	8	100.00	—	—	—	—

B. Life Table For The Adult Males Of Anderson.

x	d'_x	d_x	l_x	q_x	L_x	e^o_x
15–19.9	2	10.53	100.00	.105	473.68	24.0
20–24.9	1	5.26	89.47	.057	434.20	22.9
25–29.9	2	10.53	84.21	.125	394.73	17.8
30–34.9	2	10.53	73.68	.143	342.08	15.0
35–39.9	2	10.53	63.15	.167	289.50	12.1
40–44.9	4	21.05	52.65	.400	210.55	9.0
45–49.9	2	10.53	31.57	.334	131.53	8.3
50–54.9	1	5.26	21.04	.250	92.05	6.3
55–59.9	3	15.78	15.78	1.000	39.45	2.5
Total	19	100.00	—	—	—	—

C. Life Table For The Adult Females Of Anderson.

x	d'_x	d_x	l_x	q_x	L_x	e^o_x
15–19.9	3	17.65	100.00	.177	455.88	23.7
20–24.9	1	5.88	82.35	.071	396.05	23.2
25–29.9	1	5.88	76.47	.077	367.65	19.8
30–34.9	1	5.88	70.59	.083	338.25	16.3
35–39.9	2	11.76	64.71	.181	294.15	12.5
40–44.9	3	17.65	52.95	.333	220.63	9.7
45–49.9	2	11.76	35.30	.333	147.10	8.3
50–54.9	1	5.88	23.54	.250	103.00	6.3
55–59.9	3	17.65	17.65	1.000	44.15	2.5
Total	17	100.00	—	—	—	—

*Note: For Footnotes On Headings See Table 1.

tween the two study groups with respect to the age and sex distribution of the burials suggested that the mortality frequencies noted for the subsample of 44 adequately reflected the mortality profile of the Anderson population. The only limitation may be an under-estimation of mortality rates for the subsample of 44.

Infectious Disease, Malnutrition, And Mortality. The infectious lesions tentatively identified on the Anderson skeletal material included periostitis and severe osteomyelitis. The possible nutritional disorder was identified as porotic hyperostosis (Lallo and Blank 1977). The lesion may have a dietary origin and can be expressed as cribra orbitalia, spongy hyperostosis, or osteoporotic pitting (see Carlson *et al* 1974; El-Najjar *et al* 1975; Lallo *et al* 1977; and Mensforth *et al* 1978).

Scrimshaw's (1964, 1966) analyses of the ecology of infectious disease demonstrated that the synergistic interaction of suboptimal nutrition and infectious disease can be an important factor in the mortality experiences of a population. Episodes of infectious disease can affect both sub-adults and adults; however, the most serious consequences are usually expressed by the sub-adults. Usually the interaction of dietary malnutrition and infectious disease can result in weaning diarrhea, which, because of nutrient loss and fluid dehydration, compounds the effects of the malnutrition and can render the host less resistent to infectious disease. Also, Weinberg (1976) pointed out that episodes of infectious disease can result in a reduction of blood iron levels, which, in turn, can exacerbate the effects of the malnutrition. The net effect is an interaction system that can inflate the mortality experiences of a population. Although the effects are most serious for the sub-adults, the adults also suffer in that the interaction of suboptimal nutrition and infection can lower the general level of health and may function as a selective agent with resultant differential mortality.

Within the subsample of 44, 81.8% (36) of the individuals displayed osseous evidence of infectious disease, and 65.9% (29) exhibited porotic hyperostosis. The observed difference between pathological and non-pathological individuals was significant at .001 ($\chi^2=17.8$) for infectious disease, and at .05 ($\chi^2=4.5$) for porotic hyperostosis. Of the 36 individuals with infectious disease, 80.6% (29) also had porotic hyperostosis associated with the infectious disease. For the Anderson population, the association of infectious disease and porotic hyperostosis was significant at .001 ($\chi^2=13.4$). In general, all of the cases of porotic hyperostosis were associated with infectious disease, and in no case did porotic hyperostosis occur as an isolated or an independent lesion.

It was possible to break the subsample of 44 into several demographic units (e.g., sub-adults, adults, etc.) and examine the association of infectious disease and porotic hyperostosis. For the sub-adults, 87.5% (7) showed an infectious lesion, and the difference observed between infected and non-infected sub-adults was significant at .05 ($\chi^2=4.4$). Of the 7 sub-adults with infectious disease, 100.0% (7) also had porotic hyperostosis in association with the infection. This association was significant at .05 ($^2\chi=4.5$).

Within the adult segment of Anderson, 80.6% (29) displayed an infectious disease, and the difference between infected and non-infected individuals was significant at .001 ($\chi^2=13.4$). Of the 29 adults with infectious disease, 75.9% (22) also exhibited porotic hyperostosis. The association of infectious disease and porotic hyperostosis was significant at .01 ($\chi^2<9.1$). If the adults are separated according to sex, 84.2% (16) of the 19 adult males had infectious disease, and 76.5% (13) of the 17 adult females exhibited the lesion. For both the males ($\chi^2=9.0$, $P<.01$) and females ($\chi^2=4.7$, $P<.05$), the difference observed between pathological and non-pathological individuals was significant.

Of the 16 males with infectious disease, 62.5% (10) also had porotic hyperostosis, and of the 17 adult females with infectious lesions, 70.6% (12) also exhibited porotic hyperostosis. The association of porotic hyperostosis and infectious disease among the adult males was not significant until the .20 level ($\chi^2=2.2$); however, for the adult females, the association was significant at the .05 level ($\chi^2=4.4$). The interaction of malnutrition and infectious disease may have been an important factor in adult female mortality.

For the Anderson population, mortality frequencies were highest in the following age classes: 5 to 9.9, 15 to 19.9, 40 to 44.9, and 55 to 59.9 years. Of the 21 individuals in these 5 age classes, 81% (17) exhibited osseous evidence of both porotic hyperostosis and infectious disease. The difference between pathological and non-pathological individuals was significant at .01 ($\chi^2=6.6$). For the sub-adults in the Anderson population, the synergistic interaction of malnutrition and infection may have directly inflated sub-adult mortality. For the adults, the interaction of malnutrition and infectious disease may have influenced the general level of health and may have contributed to some differential mortality, especially among the adult females. The associations between infectious disease, malnutrition, and mortality strongly suggest that such interactions can be an important factor in the mortality experiences of the Anderson population. The results do not suggest that these variables were the only factors in mortality, but they do suggest that infectious disease and malnutrition were closely associated with population mortality in one of Ohio's early American Indian groups.

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