International Journal of Paleopathology 17 (2017) 26–39

Contents lists available at ScienceDirect

International Journal of Paleopathology

journal homepage: www.elsevier.com/locate/ijpp

Invited commentary

Life not death: Epidemiology from skeletons

George R. Milner[a,*], Jesper L. Boldsen[b]

[a] Department of Anthropology, 409 Carpenter Building, Pennsylvania State University, University Park, PA 16802, USA
[b] Unit of Anthropology [ADBOU], Department of Forensic Medicine, University of Southern Denmark, Lucernemarken 20, DK 5260 Odense S, Denmark

ARTICLE INFO

Article history:
Received 8 August 2015
Received in revised form 7 March 2017
Accepted 14 March 2017
Available online 12 April 2017

Keywords:
Paleoepidemiology
Heterogeneity in frailty
Selective mortality
Skeletal lesions
Archaeological skeletons

ABSTRACT

Analytically sophisticated paleoepidemiology is a relatively new development in the characterization of past life experiences. It is based on sound paleopathological observations, accurate age-at-death estimates, an explicit engagement with the nature of mortality samples, and analytical procedures that owe much to epidemiology. Of foremost importance is an emphasis on people, not skeletons. Transforming information gleaned from the dead, a biased sample of individuals who were once alive at each age, into a form that is informative about past life experiences has been a major challenge for bioarchaeologists, but recent work shows it can be done. The further development of paleoepidemiology includes essential contributions from paleopathology, archaeology or history (as appropriate), and epidemiology.

1. Introduction

Paleoepidemiology is a relatively new approach to characterizing the life experiences of prehistoric and historic-period peoples (Boldsen, 2001; Boldsen and Milner, 2012; Dutour, 2008; Pinhasi and Turner, 2008; Waldron, 1994, 2007). While closely related to paleopathology because it is based on sound observations of disease processes in skeletons, paleoepidemiology employs different analytical procedures and has distinctive objectives. Immediate challenges include obtaining accurate age-at-death estimates, addressing problems posed by the use of mortality samples, and developing methods that owe much to epidemiology.

At the outset, it is important to realize that populations, not individuals, are of interest. That distinguishes paleoepidemiology from case studies featuring one or a few skeletons, which are common in paleopathological research. The latter include much of what might be called osteobiography, a term coined by Saul (1972), which sometimes features rich contextual information supplementing skeletal findings (Knüsel et al., 2010). Paleoepidemiological analyses are also not concerned with documenting the presence of specific diseases in the past through highly distinctive modifications of hard tissue matched to clinical observations, coupled with age, sex, and geographical setting. That important aspect of paleopathology is often referred to as differential diagnosis, following Buikstra's (1976) lead forty years ago. Differential diagnosis and paleoepidemiology, however, share one fundamental characteristic: they are probabilistic in nature because both involve uncertainty over linkages between observable pathological processes and specific diseases. Differential diagnoses in paleopathological studies are not known for having adopted an explicitly quantitative approach, partly because single skeletons are often of interest, but there has been some movement in that direction (Byers and Roberts, 2003). In contrast, paleoepidemiology, as defined here, is squarely centered on estimating the association of skeletal lesions with specific diseases and the relative risk of dying. That information is then used to assess the life experiences of people categorized by sex, age, community affiliation, and so on.

Paleoepidemiology is similar to the aspect of paleopathology that focuses on the disease experience of past groups of people, especially the consequences for health of new ways of life, such as the development of agricultural economies and organizationally complex societies. Individual skeletons are of little concern, except that they provide the raw data upon which inferences are based. There is, however, an important distinction to be made between paleopathological and paleoepidemiological studies that deal with past disease experience. The former tend to rely on frequencies of bone and dental lesions in cemetery samples, and it has often been assumed that more lesions mean sicker people. Paleoepidemiological analyses start with such frequencies, but expressly tackles the challenges inherent in drawing inferences about once-living populations from mortality samples, first discussed at length a quarter-century ago (Wood et al., 1992). That includes sometimes

* Corresponding author.
E-mail addresses: ost@psu.edu (G.R. Milner), jboldsen@health.sdu.dk (J.L. Boldsen).

http://dx.doi.org/10.1016/j.ijpp.2017.03.007
1879-9817/

counterintuitive results that stem from a proper accounting of the biased nature of skeletal samples.

A principal goal of paleoepidemiology is the generation of results interpretable within the context of modern medicine and epidemiology, notably an increased risk of dying associated with various pathological features of bones and teeth. Analyses of archaeological skeletons are thereby brought more closely in line with investigations of contemporary or near-recent populations that rely on clinical trials, case-control studies, historic or prospective cohort studies, public health surveys, and death registers. Although paleoepidemiological studies are not there yet, they have the potential for bridging a chasm that separates what can be generated from archaeological skeletons and information gleaned from modern clinical settings and public health surveys.

Despite common elements between paleoepidemiology and standard epidemiology, they are far from the same. Most notably, paleoepidemiology is based on the characteristics of skeletons, not of living people. Anything derived directly from mortality samples differs from clinical or historical descriptions of people examined when alive. In that sense, paleoepidemiology is similar to epidemiological analyses of death registers. Despite differences between the two fields, they share common objectives. Of special concern are the effects of disease processes on mortality estimated for the population as a whole, or subsets of it; the resulting cost to communities of impaired and shortened lives; and the impact of different ways of life on morbidity and mortality. That is where the goals of studies that shed light on the disease experiences of past and present populations coincide with those of evolutionary medicine.

Paleoepidemiological work complements archaeological research oriented toward understanding past social organizations, economic systems, intergroup relations, and general living conditions. For several decades, archaeologists have focused much of their attention on how past communities were organized and functioned. Paleoepidemiological studies add a quantifiable public health dimension, which up to now has been missing, to the archaeological research effort. For example, estimates of the relative risk of dying with observable pathological conditions can be followed by assessments of what those lost years of life meant to the productive capacity and social fabric of past communities. More secure understandings of long-term trends in morbidity and mortality contribute to archaeological studies of changes in sociopolitical and economic systems, technological innovation, and population growth (Larsen, 2002; Steckel and Rose, 2002; Wood, 1998). Without that human dimension – the relative benefits and costs of various ways of life – archaeological models of cultural evolution omit critical components. After all, disease experience and population characteristics, such as life expectancy, are closely related to the success and resiliency of cultural adaptations to specific environmental settings.

2. Why paleoepidemiology?

As previously noted by Waldron(1994:3-4, 2007:17-19), studies characterized as paleoepidemiology have been around for quite some time. Here we skirt a definitional quagmire, and we simply say that looking forward, it is useful to adopt a more restrictive view of what might be considered paleoepidemiology. This research endeavor faces formidable challenges, but progress is being made toward their resolution. First, the special nature of mortality samples must be explicitly addressed. Second, the results should be interpretable within an epidemiological context, notably estimates of the relative risk of acquiring a pathological condition and the associated increased risk of dying with it. Third, the estimates of prevalence in once-living populations and the biological cost in lost years of life must be embedded within their appropriate cultural context.

There are at least three reasons why paleoepidemiological studies must go beyond simple bone and tooth lesion frequencies, often with skeletons divided by sex and broadly defined age groups. They are inseparable, but for convenience are discussed in turn.

First, paleoepidemiology is concerned with documenting past life experience through studies of morbidity and mortality, especially the risks people faced and the means of mitigating them, while contributing to an understanding of how and why societies changed over time. The concern is mainly to quantify the human cost of disease processes and trauma to entire societies and various segments of them, including individual communities. In this context, pathological alterations of skeletal and dental structures serve as markers of an altered risk of dying. When combined with contextual information from other archaeological materials, estimates of early mortality attributable to illness and injury provide invaluable perspectives on what people experienced, the potential for surplus labor, the number of dependents relative to producers, the segments of society that were especially (dis)advantaged, and the like.

Estimating disease prevalence from archaeological bones and teeth is no easy task (Boldsen and Milner, 2012; DeWitte and Stojanowski, 2015; Ortner, 1991; Wood et al., 1992, Wright and Yoder, 2003). A healed skeletal lesion indicates an individual survived whatever resulted in the abnormal alteration of bone. Those without lesions perhaps never experienced what could cause a particular skeletal outcome. They could also be people who became ill with an infectious disease, but shrugged it off before a bony lesion developed, or those who died before a distinctive bony response had time to form. An absence of skeletal lesions, therefore, could indicate something that was either good or bad for the individual in question.

Despite the interpretive difficulties posed by skeletons with or without particular kinds of lesions, we remain optimistic. Any indicator of a pathological process in bones or teeth can be used to illuminate past lives if it is considered within a proper analytical framework. All that is necessary is for the lesion to be sufficiently distinctive so it can be identified with low observer error and to be associated with an increased risk of dying. The skeletal or dental lesion need not be a cause of death. For example, healed bone fractures in skeletal remains have been associated with an increased risk of dying for survivors of injuries (Boldsen et al., 2015; Milner et al., 2015). Identifying why that might have occurred propels us beyond bones into other realms, notably modern medicine, epidemiology, and historical and archaeological studies of past living conditions.

Second, it is important to compare skeletal samples appropriately, and to contrast the experiences of past people with those of their living descendants. Information from skeletons should be in a form that allows comparisons with data gleaned from historical documents and far more plentiful modern community to national-level statistics. Of particular interest is the possibility of furthering our understanding of host and pathogen coevolution (Wolfe et al., 2007), especially as measured through disease outcomes, specifically mortality in archaeological samples. The impact of diseases that affect the skeleton must have varied among people who pursued very different ways of life, including those far removed from situations that are familiar to us today.

Third, documenting how non-lethal pathological conditions, whatever their origin, affected the subsequent life course is a critical part of assessing the challenges faced by people in the past. In modern populations, illnesses, nutrition, and living conditions can influence morbidity and mortality rates much later in life (Barker, 1990; Costa, 2003, 2012; Elo and Preston, 1992; Hayward and Gorman, 2004; Kauhanen et al., 2006; Mosley and Gray, 1993).