1 The European History of Health Project

Introduction to Goals, Materials, and Methods

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1.1 Introduction

This introductory chapter describes a large collaborative effort by European and American researchers who used the same protocol to record health indicators from the skeletal remains of 15 119 individuals that were buried at 103 localities across the continent of Europe (representing 16 modern European countries) dated from the third to the end of the nineteenth century. The effort extends an earlier but smaller project for the Western Hemisphere (Steckel and Rose, 2002) by collecting data on more skeletal indicators of health, by adding a substantial number of contextual variables to aid interpretation, by recording the percentage of bone present on many skeletal elements, and by incorporating bio- and geochemical analyses. Project leaders developed computer-based software that used images to illustrate coding protocols, and created a series of tests to measure inter-observer error. Project members systematically analyzed the data to provide customized results to individual researchers for interpretation. Regular meetings in Europe and the USA helped to manage the logistics and organization needed to refine the skeletal data collection codebook, train data coders in the software, and select skeletal collections housed in European institutions for study.

1.2 Background

The study of past human health and living conditions has long been a central area of interest for physical anthropologists and other natural and social scientists (Aufderheide *et al.*, 1998; Cohen and Crane-Kramer, 2007; Grauer, 2012; Larsen, 2015; Ortner, 2003; Pinhasi and Mays, 2008; Roberts and Manchester, 2005). This project is the first large-scale attempt to track and interpret the history of human health in Europe. Our work stems from a smaller, more focused effort on the Western Hemisphere that originated in 1988, when Richard Steckel and Jerome Rose began to coordinate physical anthropologists, economists, and historians in a retrospective study of health centering on the quincentennial of 1492 CE. Building upon ideas in *Paleopathology at the Origins of Agriculture* (Cohen and Armelagos, 1984), they organized planning conferences held at The Ohio State University, which designed ways to pool skeletal data on the following health indicators: stature (from long bone lengths); oral health; osteoarthritis; cribra orbitalia and porotic hyperostosis; linear enamel hypoplasias; trauma; and skeletal infections (periosteal reactions).

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They envisioned using these data to document major health and lifestyle changes. Eventually, they and numerous collaborators assembled a combined database of 12 520 individuals who had been buried at 65 localities in the Western Hemisphere dating from approximately 5000 BCE to the early twentieth century. The research effort was published as *The Backbone of History: Health and Nutrition in the Western Hemisphere* (Steckel and Rose, 2002).

1.3 Aims and Objectives

The frequency and severity of skeletal lesions in the Western Hemisphere database were correlated with a variety of environmental variables such as settlement size, elevation, topography, and subsistence patterns, reflecting a strong relationship between ecology and the human population studied, as seen in living populations (McElroy and Townsend, 2009). The responsiveness or sensitivity of health to the environment in these data suggested there would be great potential for understanding the long-term evolution of human health by gathering and analyzing skeletal and environmental data from other areas of the world – in this case, Europe.

The European project substantially exceeds the Western Hemisphere project in size, scope, and complexity, and thus represents the largest research-based dataset ever amassed and analyzed in bioarchaeology. By creating several large databases, investigators and collaborators have been able to consider the history of human health from the late Roman period (the third century CE) to the late nineteenth century by pooling skeletal data from numerous skeletons. The aims of the project are to assess the extent to which human health and welfare were transformed by the diminished political and economic organization following the fall of Rome; climate change (especially the Medieval Warm Period and the ensuing Little Ice Age); population growth; the rise of Medieval cities that were later replaced by more complex forms of socioeconomic and political organization; and European colonization and industrialization. With a trans-Atlantic network of collaborators, the project undertakes a large-scale comparative study of the causes and health consequences of these and other dramatic changes impacting the lives of European ancestors.

As noted above, this project extends work performed earlier on the Western Hemisphere. It collects data on the same seven variables given above and, in addition, the osteological record of specific infectious and metabolic diseases (tuberculosis, leprosy, treponemal disease, rickets, and scurvy). However, because of lack of data, ultimately infectious and metabolic disease data are not analyzed in this volume. It also expounds upon the original seven variables by scoring more joints for evidence of osteoarthritis, defining additional degrees of severity for most variables, explicitly defining and coding for the standard suite of sex and age estimation techniques, expanding the types and locations of various traumatic lesions, and, importantly, developing a codebook with visual references to accomplish standardized coding (Steckel *et al.*, 2006). Many researchers have advocated standard data recording of skeletal remains, thus allowing datasets to be compared

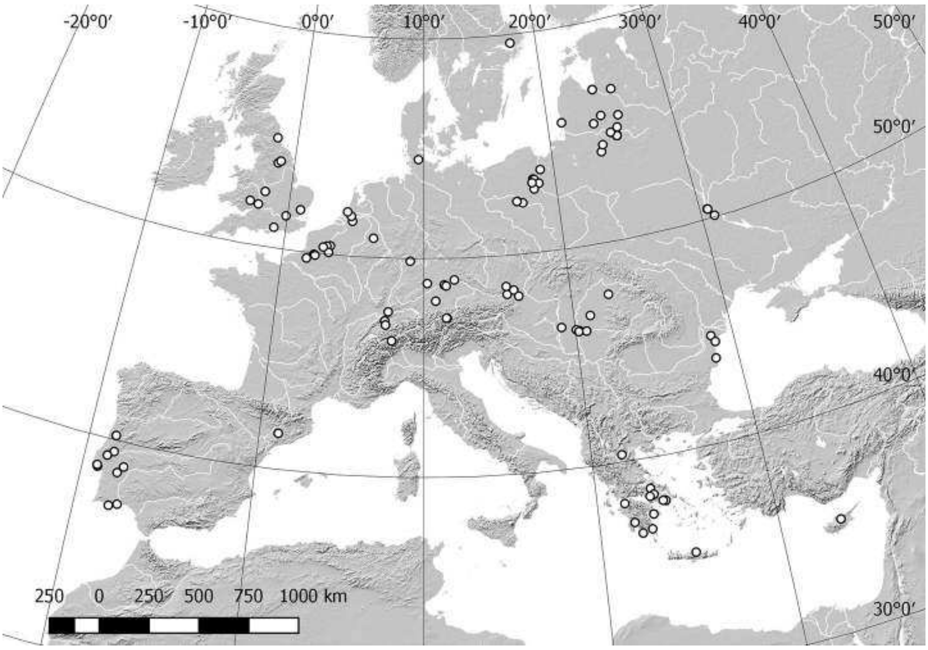

Figure 1.1 Location map of sites in the database.

(Brickley and McKinley, 2004; Buikstra and Ubelaker, 1994; Roberts and Cox, 2003). This project followed these overall recommendations.

The geographic distribution of skeletal remains analyzed in the project is given in Figure 1.1, which shows the localities of sites represented in the skeletal sample from each country. One can see that Germany, Lithuania, and the UK lead the way in data collection, with strong representation from Austria, France, Hungary, the Netherlands, Poland, and Switzerland. Other significant contributors include Greece, Latvia, Portugal, Romania, Sweden, and Ukraine. Senior investigators and their students in these countries were particularly active in the project.

1.4 Project Organization

Even before *The Backbone of History* was published, Richard Steckel, Clark Larsen, and Phillip Walker were gathering ideas for a new initiative. With funding from The Ohio State University and the National Science Foundation (BCS-0117958) to undertake a feasibility study, they organized a planning meeting at The Ohio State University in June 2001 to consider potential skeletal remains available for coding, discuss coding procedures, and to deliberate over administrative matters. A large number of senior researchers from European institutions attended this planning meeting. The European physical anthropologists reported personal access to over 130 000 skeletons at museums where they worked or conducted research.

Participants discussed and debated many issues, but in general they agreed to: (1) complete a database of skeletal collections to which they had access for study; (2) prepare a codebook that would be used to gather data from skeletal remains for the project; (3) collect contextual information about the sites where skeletal remains would be analyzed; (4) share data, although there were some qualifications or concerns expressed by a few people; and (5) prepare a grant application to the National Science Foundation to fund the larger project.

In 2002 and again in 2005 the National Science Foundation funded our ambitious project applications to carry out the work (NSF SES-0138129 and NSF BCS-0527658; Richard Steckel principal investigator, and Clark Larsen and Phillip Walker co-investigators), which involved several steps, beginning with the writing of the codebook for data collection. General agreement on the variables to collect data on solidified within a year or so, but additional details over precise definitions, and the development and collection of diagrams and photographs to illustrate disease and other data categories, took longer and extended into organizational meetings in Buffalo, New York, USA (2002); Coimbra, Portugal (2002); Leiden, the Netherlands (2003); Albuquerque, New Mexico, USA (2003); and Durham, UK (2004).

1.5 The Codebook and Software

Next came efforts to develop laptop-based software that would facilitate the data collection. The Center for Human Resource Research at The Ohio State University was an essential resource in this endeavor. The Center for Human Resource Research is widely respected for designing software to interview people for the National Longitudinal Survey in the USA, a large project in the social sciences that records a wide variety of information on repeated samples of households (www.bls.gov/nls). With some modifications we were able to "piggy-back" on their survey instruments and software, which allowed coders to "interview" the skeletal remains by completing a series of queries, beginning with the sex and age-at-death category of each individual, and an inventory of bones that potentially had diagnostic information. Thereafter, the software routed the investigator through a series of questions based on the skeletal elements available for study. At various suitable points the software screened answers for plausibility, for example by disallowing age-at-death entries for subadults that were outside the plausible age range. At any point in the process, the investigator could add comments to explain unusual situations or to describe complexities unanticipated by the codebook. The principal and co-investigators prepared a set of instructions to guide users through the software and the use of the laptop. These included directions in using the online system to upload the completed "cases," or individual data files, to the central server at Ohio State University, where they were cleaned and stored.

Although the codebook was heavily illustrated and the data collection interface displayed all the drawings and photographs needed to make categorical decisions on coding, we carefully considered the possibility of inter-observer error. Data coders were trained in various laboratories across Europe where scoring systems for some of the variables being coded varied. To address the problem, the team designed an inter-observer error quiz that was made available online. Subsequently, Donald Ortner gave us permission to access his extensive collection of over 4000 photographs of a wide range of pathological conditions (Smithsonian Institution, Washington, DC), thus providing key examples from which to assess individual skeletons. We selected approximately 75 images to illustrate various conditions relevant to the project. Next, a committee of senior researchers, including Donald Ortner, collaborated to build consensus on how to grade each condition according to the standards of the codebook and with respect to established paleopathological protocols (Ortner, 2003). Finally, "quiz takers" were asked to score pathological conditions categorized on an ordinal scale represented in the photographs. Tracy Betsinger and Richard Steckel presented results of the quiz at the European Paleopathology Association meetings in Santorini, Greece (Steckel and Betsinger, 2006). Our studies of inter-observer error by project collaborators were highly promising using photographs of lesions for various variables. On average, the scoring was identical 72 percent of the time, and virtually all departures fell into an adjacent category for categorical variables. One could not reject the hypothesis that the distribution of differences (for interior cases, such that higher or lower scores were possible) was symmetrical around the average, and we concluded that there was no systematic bias in scoring.

We organized annual project meetings in Europe to test the software; train data coders; discuss skeletal collections for coding; consider ecological or contextual variables; prepare site reports; discuss the purpose and organization of subcommittees; determine the logistics of chemical analyses; discuss progress in coding skeletal collections; make authorship arrangements; establish payment and accounting procedures; discuss the structure of data analyses and publication plans; and present preliminary results. The first of these meetings took place in Rome, Italy (January 2006), hosted by Alfredo Coppa, followed by Athens, Greece (2007; Anastasia Papathanasiou and Sotiris Manolis, hosts), Munich, Germany (2008; Gisela Grupe and George McGlynn, hosts), and Douai, France (2009; Benoit Bertrand and Pierre Demolon, hosts). Less formal but very productive gatherings also took place at the European Paleopathology Association meetings in Durham, UK (2004), Santorini, Greece (2006), Copenhagen, Denmark (2008), and Vienna, Austria (2010), as well as at the annual American Association of Physical Anthropologists meetings in Buffalo, New York (2002), Tempe, Arizona (2003), Tampa, Florida (2004), Milwaukee, Wisconsin (2005), Philadelphia, Pennsylvania (2007), Columbus, Ohio (2008), Chicago, Illinois (2009), Albuquerque, New Mexico (2010), and Minneapolis, Minnesota (2011). Finally, in 2016, a penultimate meeting was held in Tübingen, Germany (Joerg Baten, host), organized to review the resulting chapters (for which we acknowledge support by the German Science Foundation, DFG, grant SFB 1070 and BA-1503–1611).

1.6 Study Sample

The first two project meetings in Rome and Athens devoted considerable time to the selection of skeletal collections for study, a process that is described in Chapter 15.

Our goal was to create a database that contained skeletal and related contextual data that reflected the geographic, ecological, and temporal diversity of the European continent over a significant period of time, tracing the intensification of agriculture, and culminating with the later stages of industrialization. We were also cognizant of building a representative sample with regard to population demography, and obtaining sample sizes that would provide the statistical power to understand how population health changed over time in relation to selected contextual variables.

The initial strength of our collaborators' resources was clearly the access to large numbers of skeletal remains from a number of different sites representing the Middle Ages (roughly 500 CE to 1450 CE). We began coding these collections and then proceeded to identify and code earlier and later skeletal series, limited only by time and available budget. The database contains evidence from archaeological skeletal collections ranging from the Pre-Medieval period (300–500 CE) through the end of the Industrial/Modern period (*c.*1900 CE). The date ranges for which cemeteries were used for burials varied enormously across sites. A few, such as skeletal series derived from battlefield sites, were marked precisely in time, whereas other skeletal series represent accumulations of skeletal remains spanning several centuries or more. The latter sites are difficult to link with ecological variables that changed with time, such as temperature or climate, but in many cases they are seen to correlate with subsistence strategy, elevation, topography (if used by a population who lived in the same location over time), and other aspects of socioeconomic status.

1.6.1 Characteristics of the Database

Although the total database contains 15 119 individuals, numerous skeletons have incomplete information across the variables observed. Therefore, sample sizes vary across presented tables and across chapters in this volume according to the information available. Similarly, limited ecological information at some sites restricted the types of analyses that could be conducted.

Demographic features of the sample are described by the percentage of individuals distributed by sex and age at death (Table 1.1) and by time period and sex (Table 1.2). Elsewhere, these variables are further explored for only male and female adults (defined as 18+ years, or with complete epiphyseal fusion of all but the sternal end of the clavicle and iliac crest). One can see that the age distribution of deaths mainly followed a U-shape, with most deaths occurring under age ten. As is characteristic of many archaeological skeletal assemblages, the lowest share of deaths occurred in the age category of 10–19 years and rose steadily thereafter until age 50. Beyond that the frequencies decline, but this picture is clouded by ambiguities in estimating age at death, an issue well known to physical anthropologists (e.g., Chamberlain, 2006; Molleson and Cox, 1993). Of course, one cannot infer life tables from age distributions of death, which can be affected by migration and fertility and the selective nature of the archaeological record itself, but this age distribution is at least broadly consistent with what one would expect from plausible model life tables (Coale *et al.*, 1983) thought to apply to pre-modern populations. Adult men and women have a

Table 1.1 Distribution of the database by sex and age at death

Age	Male	Female	Unknown	Total	Percent
0 < 3	0	0	1243	1243	8.22
3 < 6	0	0	949	949	6.28
6 < 9	0	0	730	730	4.83
9 < 12	0	0	445	445	2.94
12 < 15	0	0	364	364	2.41
15 < 20	89	78	486	653	4.32
20 < 25	637	415	0	1052	6.96
25 < 30	578	505	0	1083	7.16
30 < 35	705	608	0	1313	8.68
35 < 40	708	574	0	1282	8.48
40 < 100	3395	2610	0	6005	39.72
Total	6112	4790	4217	15 119	100.00

Table 1.2 Distribution of database by sex and time period

Period	Male	Female	Unknown	Total
Pre-Medieval (300–500 CE)	500	429	298	1227
Early Middle Ages (500–1000 CE)	1734	1646	1459	4839
High Middle Ages (1000–1300 CE)	765	608	1001	2374
Late Middle Ages (1300–1500)	703	755	363	1821
Early Modern (1500–1800)	1966	977	875	3818
Industrial (1800–1900)	444	375	221	1040
Total	6112	4790	4217	15 119

remarkably similar age-at-death distribution. This fact, in combination with the expected mortality profile of the sample from infancy through advanced adulthood, supports the notion that this sample appropriately reflects a population structure that would be expected prior to the mortality transition of the nineteenth century.

1.6.2 Geographic and Sociocultural Diversity of the Sample

Sites currently located within the modern countries of Central Europe, England, Portugal, and Southeastern Europe are well represented in the database. Unfortunately, there are few sites from southern France, Italy, Scandinavia, and Spain. It is difficult to assess how these absences might influence the overall health profile we can draw about Europe. For this reason, future work will focus on building representation from these regions. Figure 1.1 shows the geographic distribution of the sites on a topographical map that also contains information on elevation, vegetation, and geographic coordinates (latitude and longitude). We organized elevation into discrete categories for ease of presentation of the sample sizes and some statistical work, but we also consider elevation as a continuous variable where appropriate. Many of the archaeological sites of the skeletal collections we coded were excavated during the twentieth century by different teams that had various aims and questions driving their research. Therefore, the contextual information available varied considerably across sites. It was a challenge to identify common contextual variables for all sites, but we did identify the broad but informative categories that provide an "environmental" context for the health of the sample populations we examined. That is, geographic location and sociocultural influences that affect the life experience, including health, are well represented in the foregoing analyses. These influences pertain especially to settlement pattern and socioeconomic status, of which a wide range of settlement contexts are included. The contextual variables are explained in greater detail in Chapter 2.

1.7 Preliminary Results and Authorship

The largest preliminary effort for presentation of the project's results took place at the 2009 American Association of Physical Anthropologists meeting held in Chicago, Illinois. We dedicated the symposium to Phillip L. Walker, a senior investigator of the project and an inspiration to us all, who tragically passed away in February of that year. The presentations included data and interpretation on contextual variables of the project; materials and methods; body size and femur length; osteoarthritis; linear enamel hypoplasias; oral health; traumatic lesions; osteoperiostitis; cribra orbitalia and porotic hyperostosis; rickets and scurvy; infectious disease; the health index, a summary measure of health; and stable isotope analysis.

In a large project of this sort, discussions of co-authorship were inevitable and became a staple element at project meetings. In the end our executive committee recommended that we identify senior researchers whose prior work focused on a specific topic and who would take the lead in writing the appropriate chapters. Other senior researchers made substantial intellectual, organizational, or material contributions to the chapters, but authorship was limited to those who wrote and who would be in a good position to present and to defend the chapter.

1.8 Contributions

In Chapter 2, Jankauskas and Grupe provide an overview of the context for the project, including especially the archaeological and historical background and environmental and socioeconomic record over the time period of the skeletal assemblages studied. In Chapter 3, Steckel and Kjellström provide an overall assessment of health of these populations, as provided by a health index (see Steckel *et al.*, 2002), which combines and weights equally seven attributes of health recorded in the project: (1) femur length; (2) porotic hyperostosis and cribra orbitalia; (3) linear enamel hypoplasias; (4) osteoperiostitis; (5) trauma; (6) osteoarthritis; and (7) oral health. Climate and its relationship to health status are considered by Steckel and Engel. Wherever possible, we relied on the large and growing historical record of environmental conditions (e.g., Brooke, 2014). Temporal and spatial variation in oral health (Chapter 4, Wittwer-Backofen and Engel), non-specific indicators of health (osteoperiostitis) (Chapter 5, Marques, Matos, and Meinzer), physical growth disruption and physiological stress as evidenced by linear enamel hypoplasia (Chapter 6, Bereczki, Teschler-Nicola, Marcsik, Meinzer, and Baten) and the related conditions, cribra orbitalia and porotic hyperostosis (Chapter 7, Papathanasiou, Meinzer, Williams, and Larsen), are also addressed in detail. Finally, body size and activity patterns are addressed using long bone metrics (Chapter 8, Meinzer, Steckel, and Baten), as well as by the study of osteoarthritis (Chapter 9, Williams, Meinzer, and Larsen). Baten and Steckel, in Chapter 10, examine patterns of violence across the millennia in Europe, and Roberts and Steckel (Chapter 11) explore the application of the developmental origins of health and disease to the dataset. Chapters 14 and 15 contain the codebook used, and describe the database creation and management. The editors conclude with a chapter that compares the different dimensions of human health and welfare. Collectively, these chapters explore longstanding bioarchaeologically relevant topics using the most comprehensive and diverse skeletal sample yet available. They provide a unique cross-sectional and longitudinal view of the human condition and how it evolved over key periods in our common history since the late Roman period.

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