EXAMINING SKELETAL TRAUMA ON THE NORTH AMERICAN GREAT PLAINS: APPLICATIONS OF CODED OSTEOLOGICAL DATA FROM THE SMITHSONIAN REPATRIATION DATABASE

By

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ABSTRACT

EXAMINING SKELETAL TRAUMA ON THE NORTH AMERICAN GREAT PLAINS: APPLICATIONS OF CODED OSTEOLOGICAL DATA FROM THE SMITHSONIAN REPATRIATION DATABASE

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Since the 1990s and the passage of the Native American Graves Protection and Repatriation Act (NAGPRA), museums, laboratories and universities have focused their efforts on documenting their collections of Native American human remains before materials are returned to descendants. The field of physical anthropology was forward-thinking and created a set of standards to record basic information so skeletal data could be collected and stored for use by future researchers. The Smithsonian Institution (SI) falls under a different statute, the National Museum of the American Indian Act (NMAIA), which was implemented in 1989, although Smithsonian policies now closely mirror the NAGPRA. Enactment of the NMAIA necessitated construction of a computerized database to store and manage data curated by the Institution. To date, scholars have used the osteological database for comparative purposes, but not as a primary focus of research. Using the SI's relational database and a subset of the data collected from the Institution's Native American collections, this research assesses the accessibility of the SI osteological data, functionality of the SI relational database management system, and the quality of data previously collected by the SI Repatriation Osteology Laboratory. The proposed research also aims to accomplish a geographic and temporally expansive analysis of violence using a large dataset of Arikara-related skeletal materials curated at the museum.

The SI database provided large-scale, time-space distributional data for use in a macro-regional and -temporal analysis. Utilization of archival databases to address anthropological

research questions allows us to identify patterns that only become visible in samples larger and more widely geographically and temporally distributed than can be collected by any single individual or at one point in time (Steckel et al. 2002). Increasing the temporal and geographic range of samples can increase the breadth of understanding of the deep human past by allowing researchers to see changes through time and space, as well as interpersonal interactions between, and not only within, a single population.

The present research provides evidence that violence in the Arikara tribe was a long-standing cultural tradition that pre-dated European contact. While injuries tended to accumulate with age in both sexes, different patterns of injury occurred between males and females. The patterns of injury suggest that intertribal raiding was the most common method of warfare practiced in both the Pre-Contact and Post-Contact periods. Instead of contact with Euro-Americans perpetuating and increasing the frequency of intertribal raiding, there appears to be a continuance of long-standing violent engagements from the proto-historic through the early historic period. A general lack of evidence of high mortality in Young Adult males (contrasted with other sex and age groups) and the low frequency of perimortem trauma were also consistent with small-scale raiding as the primary form of aggressive intertribal interactions in the Middle Missouri River Basin.

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The data used in this dissertation is the result of efforts initiated more than 70 years ago. The River Basin Surveys (RBS) Program, under the direction of the Smithsonian Institution from 1946 to 1969, made a number of significant contributions to American archaeology (and bioarchaeology) including illuminating the culture history of much of the United States. Much of the data used in this research was collected from skeletal remains recovered from the RBS. One of the goals of the RBS was to preserve our nation's archaeological history and a large number of skeletal remains collected under the program were subsequently curated by the Smithsonian. Following the passage of repatriation legislation in the late 1980s, many of the skeletal materials recovered by the RBS were scheduled for return to descendant groups. In an effort to preserve archaeological data for future research, the field of Physical Anthropology developed standards of data collection. The Smithsonian, in turn, pioneered the collection and digitization of osteological data. In this sense, more than 70 years of work have contributed to the present research.

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KEY TO ABBREVIATIONS

AMM	Army Medical Museum
GUI	Graphic User Interface
IASP	Interagency Archaeological Salvage Program
NAA	National Anthropological Archives
NAGPRA	Native American Graves Protection and Repatriation Act
NMAIA	National Museum of the American Indian Act
NPS	National Park Service
NMNH	National Museum of Natural History
RBS	River Basin Surveys
RDB	Relational Database
RDBMS	Relational Database Management System
ROL	Repatriation Osteology Laboratory
SI	Smithsonian Institution

CHAPTER I: INTRODUCTION

In recent years, skeletal analysis and collection of data from human skeletal remains have been endowed with a sense of urgency following enactment of federal repatriation legislation. This dissertation addresses a number of fundamental issues pertaining to the collection and curation of osteological data in the field of bioarchaeology. Of particular importance, this research will explore how we record osteological data, how we curate digital osteological data, and how we make this data available to future researchers. Using the Smithsonian Institution's (SI) relational database and a subset of the digital data exported from the Institution's Native American collections, this research assesses the usability of the SI relational database management system, accessibility of osteological data, and the quality of data previously collected by the SI Repatriation Osteology Laboratory (ROL).

Since the passage of the National Museum of the American Indian Act (NMAIA), Public Law 101-185, in 1989 and the Native American Graves Protection and Repatriation Act (NAGPRA), Public Law 101-601, in 1990, museums, laboratories and universities have been focused on documenting their collections of Native American human remains before materials are offered for repatriation to culturally affiliated descendants. Before repatriation legislation, SI documentation was not systematic and was often dependent on curator interests (Ousley et al. 2005). Likewise, other museums and institutions across the country collected skeletal data in idiosyncratic formats with little effort devoted to data standardization. The field of physical anthropology was forward-thinking in creating a set of standards to record basic information about each skeleton so that data could be collected and placed into databases for use by future researchers. *Standards for Data Collection from Human Skeletal Remains ("Standards",* Buikstra and Ubelaker 1994) was developed in response to repatriation legislation in an effort to minimize the loss of data and maximize comparability of data between institutions across the country (Ousley et al. 2005). The value of standardized data is apparent when one considers the significance of large scale comparisons. Unlike specialized data, which can only be used to answer specific research questions, large, standardized datasets can increase the breadth of research and our understanding of human history by uncovering unusual, unexpected, or previously unknown patterns within a skeletal collection that only emerge in large-scale datasets (Ousley et al. 2005). Ultimately, repatriation legislation caused several significant changes in physical anthropology, including: (1) eliminating gaps in our understanding of temporal periods and geographic ranges; (2) osteological data collection and analyses are more comprehensive than ever before; (3) curation facilities are improving and transitioning into digital curated samples; and, (4) most importantly to this research, the establishment of large-scale databases generated from the osteological data collected from Native American collections which allow for macro-regional and -temporal analyses (Rose et. al 1996).

The Smithsonian has been a pioneer in building scholarly databases from osteological data collected from human skeletal remains. Unfortunately, there has been little focus on whether or not the SI database can be used for original research questions. Scholars have used the database for comparative purposes, but not as a primary focus of research. The Smithsonian collections are particularly important because the institution has been at the forefront of the repatriation effort and has assembled one of the largest collections of Native American materials in the world. Following the offer of repatriation, the majority of the SI Native materials are no longer physically available for study due to either reburial or restrictions imposed by the institution's repatriation policy. The present research evaluates the extent to which the

Smithsonian's relational database can be used as a primary source of data and for comparative purposes. This project is aimed at testing the usability of the data collected following the enactment of the NMAIA. All data used in this project is currently curated at the SI and was collected on behalf of the ROL between the years 1993 and 2012. Following Smithsonian policy, skeletal remains and associated artifacts are no longer available to researchers. Consequently, this study is based solely on the data previously recorded by ROL staff.

Because my interests fall within the realm of trauma analysis, this research also provides a geographic and temporally expansive analysis of violence, using a large dataset of Arikara-related skeletal materials and artifacts inventoried at the SI. The Arikara material was selected because it is one of the best documented tribes (both in terms of the literature and previous bioarchaeological analyses) and one of the largest samples curated at the Institution. While the research is focused specifically on trauma in one particular village group, the methodology outlined in this dissertation is applicable to any subset of the SI collections and to answer any set of bioarchaeological research questions, albeit with minor modifications to the general technique. The main impetus for the research is the development of a set of standard operating procedures when working with the SI relational database management systems (RDBMS), the application of data mining techniques to the SI relational database (Osteoware), and the application of a data-driven approach to studying a large sample of anthropological data.

This research is of fundamental importance to the field of bioarchaeology because it has the potential to improve methods of data collection and increase our understanding of human violence in the past. The SI collections offer a unique opportunity to conduct a statistical analysis of more than 1000 Arikara, many of whom exhibit osteological indicators of traumatic injury. Because traumatic injuries have been previously recorded and entered into the database for all

Arikara individuals, this study conducts multivariate statistical analyses on a sample of data drawn from a population that spans both space and time. Utilization of the SI database has another advantage: it is unrealistic for a single individual today to collect data from a sample of this size and scope. The purpose of the study is to determine if original research can be conducted using only the data previously collected in the ROL. With the enactment of the NMAIA and NAGPRA, and the repatriation of Native American human remains and associated artifacts, the creation and utilization of large digital data repositories may provide the only opportunity future researcher have to study this historic group.

OUTLINE OF THE DISSERTATION

As stated previously, this dissertation addresses a number of important issues in the field of anthropology: specifically, how we record osteological data, how we curate digital osteological data, and how we make this data available to future researchers. With the passage of repatriation legislation, access to large collections of human skeletal materials has greatly diminished, both through the offer of repatriation and reburial. Chapter Two outlines the relevance of this research for the future of anthropology, as well as the history of data collection and standardization in physical anthropology. Chapter Two also presents the project goals.

Chapter Three discusses the history of repatriation legislation in the United States and the impact of repatriation on museums and federal institutions. Following the discussion of repatriation legislation and the SI collections, the chapter outlines the SI's efforts to digitize osteological data collected from Native American collections before remains were offered for repatriation.

Chapter Four presents the historical background for the dissertation. This chapter discusses the Great Plains geography and climate and the history of archaeological investigations in the region. It also presents the history of the Arikara tribe. Chapter Four closes with a discussion of archaeological, ethnographic, and historical evidence of warfare on the Plains.

Chapter Five outlines the research questions and hypotheses guiding this project. Chapter Six presents the materials, including the Smithsonian's relational database and relational database management system. The chapter also presents a brief overview of each of the ten archaeological sites assessed in this study. Chapter Seven outlines the methods utilized in this dissertation. The methods chapter includes an assessment of working with the Smithsonian digital osteological collections and outlines the statistical methods employed in the trauma analysis.

Chapter Eight presents the results of the skeletal trauma analysis and observations on the functionality and usability of the Smithsonian database, Osteoware, and relational RDBMS, Advantage Data Architect™. Chapter Nine synthesizes the results of this study and presents several interpretations of the skeletal trauma data and the role of warfare and interpersonal violence on the Plains from the protohistoric through the early historic periods. Chapter Ten closes with the importance of this research for our understanding of violence in Native American cultures. This chapter concludes with a discussion of future directions for research using large-scale, digitized osteological data.

CHAPTER 2: PROJECT RELEVANCE & RESEARCH GOALS

According to the American Indian Ritual Object Repatriation Foundation (AIRORF), the SI has been a pioneer and proponent of Native American scholarship since the middle of the nineteenth century (AIRORF 1996). Of particular importance to the present study, the National Museum of Natural History (NMNH) assembled one of the country's most extensive collections of Native American items from every geographic area and nearly every tribe in the western hemisphere (AIRORF 1996). The vast extent and variety of the SI collections reflects the variable interests and research objectives of the scholars, collectors, and explorers who have contributed to the collections over the past 150 plus years (AIRORF 1996). The SI collections span the breadth of departments, including the NMNH osteological collections curated by the Department of Anthropology, ethnographic, ethnohistoric, and archaeological materials housed in the National Anthropological Archives (NAA) located in the Museum Support Center, and Native American items stored in the Human Studies Film Archives (AIRORF 1995). In summary, the SI possesses more than 4 million items affiliated with Native American groups (AIRORF 1996). Of these items, roughly 1.4 million items come from North America, including: 1.3 million archaeological artifacts, 100,000 ethnographic objects, 200,000 photographs, and more than 2 million pages of unpublished materials related to ethnography, language, literature, history and current affairs (AIRORF 1996:45). Additionally, more than 18,000 sets of human remains are culturally affiliated with Native North American tribes.

STANDARDIZATION IN THE FIELD OF PHYSICAL ANTHROPOLOGY

In physical anthropology, academic interest in human skeletal biology led to significant gains in our understanding of human history. The study of human remains from archaeological sites provides insights concerning health, diet, genetic relationships, microevolution, and population demography (Buikstra and Ubelaker 1994). As the field of anthropology evolves, profound changes in methodology and research equipment allow scientists to pursue research interests that were previously impossible. Before repatriation legislation, anthropologists studying skeletal biology in North America frequently conducted research on Native American remains excavated from archaeological sites across the country (Buikstra and Ubelaker 1994). The study of these particular remains ultimately led contemporary Native groups to begin expressing concern over the unregulated excavation and analysis of their ancestors. Many contemporary Native American tribes argued that because of their ancestral relationships to the skeletal remains being analyzed, the disposition of these remains should be controlled primarily by the descendant groups. Concern for Native American sentiment ultimately led to the development of numerous state laws that restricted the excavation and analysis of Native human remains in the United States (Ubelaker and Grant 1989).

In the 1980s, repatriation issues garnered the attention of the United States Congress as museums and Native American organizations focused increased attention on this controversial topic (Ousley et al. 2005). In 1985, the SI, recognizing that Native American tribes may not be aware of the enormity of their physical collections, mailed summaries on behalf of the NMNH to tribal leaders of 241 federally recognized tribes (Ubelaker and Grant 1989:255). Four years later, in 1989, the Heard Museum and the Barry M. Goldwater Center for Cross-Cultural Communication, with support from the Senate Select Committee on Indian Affairs of the 100th

Congress, organized an open dialogue between museums and tribal representatives referred to as the "National Dialogue on Museum-Native American Relations" (Ousley et al. 2005:4). While these discussions were underway, a number of bills relating to repatriation were proposed in Congress and eventually one bill, the NMAIA (Public Law 101-185), became law in 1989 (Ousley et al. 2005:4). The NMAIA required the SI to identify, inventory, and offer for repatriation, American Indian, Alaska Native, and Native Hawaiian human skeletal remains and associated funerary objects. The NMAIA was amended in 1996 (Public Law 104-278) to include provisions for the repatriation of unassociated objects, sacred objects, and objects of cultural patrimony. The NMAIA pertains to all Smithsonian Institutions in possession of large Native-derived collections, primarily the NMNH and the National Museum of the American Indian.

Enactment of repatriation legislation prompted the scientific community to voice concern for the loss of knowledge that would result from the repatriation of human skeletal remains and artifacts. Archaeologists and physical anthropologists, while sympathetic to Native American concerns, recognized the changing landscape of the field and predicted the imminent loss of knowledge for future researchers as new technologies were developed and innovative research methods emerged. Likewise, scientific investigative principles based upon the reproducibility of results would be compromised by repatriation and reburial of Native collections or a loss of access to skeletal collections for scientific study (Buikstra and Gordon 1981). While scientists recognized the need to collect as much data as possible in a short period of time, there was recognition that the data must be collected by highly trained individuals and in a comparable format. At this time, no standard data collection protocols existed within the field of physical anthropology and the variety of data and the formats in which data were collected were so widely disparate that it was exceptionally difficult to compare independent datasets. Of even greater concern was the possibility of collections being reburied without any scientific study or, at best, only limited analysis.

The immediate response to scientific concerns over repatriation focused attention on developing standard methods for studying large collections of skeletal remains efficiently and effectively (Buikstra and Ubelaker 1994:2). Anthropologists recognized the "need to gain the maximum amount of information from skeletons that will soon be unavailable creates an unusual challenge to the discipline of physical anthropology – demanding broad, problem-oriented data collection and creative, futuristic thought" (Buikstra and Ubelaker 1994:2). *Standards* (Buikstra and Ubelaker 1994) were developed as a protocol that were not too extensive, time-consuming, complicated or difficult for the researcher to implement. Standard protocols were initiated as a means of countering the threat of the loss of information from Native-derived collections. The goals of *Standards* were to collect comparable datasets, accommodate existing research goals and those likely to emerge in the future, gather data from large skeletal populations in a timely manner, and return Native remains to the appropriate tribes (along with the retention of remains that were not culturally affiliated with Native groups; Buikstra and Ubelaker 1994). Finally, and most importantly, standards aimed to generate large datasets of usable data for both contemporary and future researchers.

Efforts to study collections in the timeline established by repatriation legislation presented monumental challenges to the scientific community and institutions holding collections of human skeletal remains, including a significant investment of money, time, and resources. Federal deficits further stretched the ROL's resources and as such, less than 10% of the ROL budget was devoted to the documentation of the SI skeletal collections (Dr. William Billeck, personal communication on March 29, 2016). The primary goal of *Standards*, to develop an efficient and effective standard of establishing cultural affiliation of Native human skeletal remains, was evidently accomplished and is demonstrated by the enormity of the SI digital osteological database. Approximately one-third of all Native American human remains from the United States have been offered by the SI, to Native groups, for repatriation (Dr. William Billeck, personal communication on March 29, 2016). To date, the data collected from the SI repatriation collections has been widely used for comparative purposes. However, little time or effort has been devoted to testing whether repatriation data can be used, independently of skeletal remains, in bioarchaeological research.

RESEARCH GOALS

The primary goal of this research is to assess the accessibility and functionality of the Smithsonian's Relational Database (RDB), Osteoware, and Relational Database Management System (RDBMS), Advantage Data Architect™, for use in original research. While large digital repositories of osteological data have been constructed for the curation of physical anthropology data, there has been little effort towards determining whether these databases can be used as stand-alone resources, without access to skeletal materials. This research addresses two broadly theoretical hypotheses: (1) in conjunction with photographic, radiographic, ethnographic and ethnohistoric materials, high quality, holistic research can be conducted using the digitized osteological data collected from repatriated collections; (2) the use of large-scale databases of osteological data allows researchers to conduct a more comprehensive assessment of temporal and regional patterns of violence.

In addition to the accessibility and functionality of the SI RDBMS, this study also provides a temporal and regional synthesis of traumatic injury patterns among the Arikara who lived in the

Middle Missouri River Valley in the Extended and Post-Contact Coalescent periods. Data were drawn from Osteoware, SI ethnographic and archaeological collections, as well as published and unpublished sources pertaining to ten archaeological sites in the Middle Missouri River Basin. This research also addresses three hypotheses pertaining to interpersonal violence on the Plains, including: (1) males are expected to show higher levels of violent interaction and different patterns of injury due to their increased involvement in warfare, as suggested in the ethnographic literature; (2) osteological indicators of violence increased in the Missouri River Valley from the Extended Coalescent (A.D. 1500 - 1650) to the Post-Contact Coalescent (A.D. 1650 - 1886) variants; and (3) patterns of violent interaction changed from the Pre-Contact to the Post-Contact period as tribes transitioned from inter-tribal warfare to a more equestrian lifestyle with warfare involving Europeans and European derived trade goods (i.e. guns and metal weapons).

The present research focuses specifically on the Arikara for a number of reasons. First, the Arikara sample is one of the largest and best preserved in the SI collections. Additionally, the Arikara tribe is one of the best documented and most thoroughly studied tribes, in large part due to the Smithsonian RBS Program (discussed in the next chapter). Arikara cultural history is also chronicled through the tribe's oral histories and intricate mythology. The current study is focused on applying a data-driven approach to anthropological research. Using the entire collection of human skeletal remains was not feasible because the sample spans nearly every geographic region of the United States as well as thousands of years. Therefore, the sample was reduced to provide a thorough and well-informed interpretation of violence. The author's past research focusing on the Crow Creek Site, an Extended Coalescent Arikara village, and familiarity with the region and tribal history, brings a cultural awareness and sensitivity to the study of this group in particular.

Likewise, personal experience in forensic anthropology and skeletal trauma analysis lent themselves to a study of skeletal trauma.

CHAPTER 3: BACKGROUND AND LITERATURE REVIEW

This chapter presents background on repatriation legislation in the United States and the impact of repatriation on museums and federal institutions. Following the discussion of repatriation legislation and the Smithsonian collections, the chapter outlines the SI's efforts to digitize osteological data collected from Native American collections before remains were offered for repatriation. The chapter closes with a discussion of the future of anthropology and how, as a field, we can continue to utilize the data collected from repatriated materials.

BACKGROUND AND HISTORY OF REPATRIATION COLLECTIONS AT THE SI

Repatriation Legislation

On November 28, 1989 President George W. Bush signed the NMAIA. The NMAIA applied to the SI collections and the law contained provisions requiring the repatriation of human remains and funerary objects to Native American tribes. Just under a year later on November 16, 1990, congress passed and Bush also signed the NAGPRA. The two federal laws were inextricably linked and together they helped to establish a national framework for the attainment of three specific goals: (1) the repatriation of Native American cultural items, including human remains, funerary objects, sacred objects, and objects of cultural patrimony; (2) the offer to return cultural items excavated or removed from federal or tribal lands; and (3) the prohibition of commerce in certain Native American cultural objects (McKeown 2012: xi). Repatriation laws are applicable to all federal agencies and institutions subsisting on federal funds and in possession of Native materials. Under the NAGPRA, a federal agency is defined as "any department, agency or instrumentality of the United States" and the term museum is defined as "any institution or State or local government agency (including any institution of higher learning) that receives Federal funds and has possession of, or control over, Native American cultural items," but these terms do not include the Smithsonian because the Institution was already following the legislation outlined in the NMAIA (NAGPRA 1990).

The NMAIA was initially established with the intention of transferring the collections of the Museum of the American Indian, Heye Foundation, New York, to the Smithsonian Institution and the establishment of the National Museum of the American Indian (Ousley et al. 2005). The SI set a national precedent by agreeing to the repatriation provisions set forth in the NMAIA statute which required the Institution to inventory all Native American human remains and funerary objects in possession of the Institution, and using the best available scientific and historical documentation, identify the origins of such remains and objects so that these items could be offered for return to lineal descendants (Ousley et al 2005: 4).

Because the Smithsonian was already subject to the provisions established in the NMAIA, the Institution was exempt from the NAGPRA (Ousley et al 2005:4). The repatriation requirements established by the NAGPRA in many ways parallel those already implemented by the NMAIA. However, the NAGPRA expanded many of the NMAIA provisions and added sacred objects and objects of cultural patrimony as claimable items, as well as defining unassociated funerary objects as a discrete category (Ousley et al 2005:5). Both laws were built on the concept of "cultural affiliation", a term undefined under the NMAIA, but with a statutory definition under the NAGPRA to mean that "there is a relationship of shared group identity which can be reasonably traced historically or prehistorically between a present day Indian tribe or Native Hawaiian organization and an identifiable earlier group" (NAGPRA 1990). The NMAIA standard for establishing cultural affiliation used only the "best available" documentation and therefore set a higher standard than the best practices used in the NAGPRA, which functioned under the new, less rigorous standard of preponderance of evidence (Billeck 2002). SI policy requires that cultural affiliation be based upon geographical, kinship, biological, archaeological, anthropological, linguistic, folklore, oral tradition, historical records, or other expert opinion (Ousley et al. 2005:5).

Compliance with federal repatriation legislation led museums to review their records, complete inventories and skeletal analyses, and provide summaries of their collections to both the tribes and the National Park Service (NPS), which housed the NAGPRA office (Ousley et al. 2005:12). In accordance with repatriation law, museums were required to submit their Notices of Inventory Completion by November 1995 (Ousley et al. 2005). To appreciate the magnitude of the task at hand, as well as the amount of data generated through the repatriation process, one must consider the numbers. By September 30, 2004, the NAGPRA Office of the NPS had received 1,138 inventories (from both museums and federal agencies) and 861 summaries of collections. By October 2004, affiliated remains reported to the NAGPRA Office totaled 29,284. In addition to human remains, the office received reports on 578,553 associated funerary objects, 91,901 unassociated funerary objects, 1,222 sacred objects, 274 objects of cultural patrimony, and 657 objects that were classified as both sacred objects and objects of cultural patrimony (Ousley et al. 2005:13). It is perhaps appropriate that the SI fell under its own separate law, because the institution had approximately 32,000 catalog numbers of human remains, roughly 18,000 of which represented the skeletal remains of Native Americans (Ousley et al. 2005:15). The Native American remains in the collection came predominantly from two sources, archaeological excavations, including the RBS, and the Army Medical Museum (AMM).

The River Basin Surveys

As the end of the World War II approached, American civil work planners began to organize a comprehensive water resource development project which was set to flood a large part of the nation's water courses. Dam construction was authorized with the passage of the Flood Control Act of 1944 and the intent was to utilize water resources of the Missouri River and its tributaries in Nebraska, Montana, South Dakota, North Dakota, Wyoming, Kansas, Missouri, Colorado, and Iowa (Thiessen 1999:9). Archaeologists soon recognized the impending danger to archaeological sites in the river valleys, locations thought to contain upwards of 80% of the nation's archaeological resources (Thiessen 1999:9). Recognition of the urgency to save the nation's archaeological resources gave rise to the concept of "salvage" or "emergency" archaeology (Thiessen 1999:9). Both the NPS and the SI began to develop independent plans for the salvage of archaeological sites in the Missouri River Basin (Winham and Calabrese 1998:269). Eventually NPS and the SI merged, and the cooperative archaeological effort that developed was named the Interagency Archaeological Salvage Program (IASP; Winham and Calabrese 1998:269). The SI subsequently developed the RBS as a means to uphold its part of the program (Winham and Calabrese 1998:269). The RBS were funded by the NPS and continued under SI direction from 1946 until 1969, when the unit was transferred to the NPS and became the Midwest Archaeological Center (Wedel and Krause 2001:20). "During its lifespan RBS archaeologists conducted surveys and excavations in at least 273 reservoir areas, recorded more than 5,000 archaeological sites, and conducted excavations at more than 576 of them" (as of 1965; Stephenson 1967:4). The RBS made a number of significant contributions to American archaeology including illuminating the culture history of much of the United States, especially the Missouri River Basin. In addition, the RBS advanced archaeological methods and developed a highly organized system of documentation and record keeping (Thiessen and Roberts 2009). The legacy of RBS data collection and record keeping is evidenced with this research, which uses osteological specimens collected nearly 70 years ago.

Impact of Repatriation Legislation on Museum Collections

Enactment of the two repatriation laws had a number of positive impacts on museums across the country. Before 1989, it is likely that the majority of large American museums did not have a complete or accurate inventory of their physical collections. The federal repatriation legislation forced museums to review their records, complete inventories and skeletal analyses, and provide summaries of their collections to both the tribes and the NPS (Ousley et al. 2005:12). Prior to the NMAIA, SI documentation of remains was not systematic and was often dependent on curator interests (Ousley et al. 2005). Likewise, other museums and institutions across the country collected skeletal data in idiosyncratic formats with little time devoted to standardization of data. National compliance with repatriation legislation subsequently prompted the field of physical anthropology to reconsider the process of data collection from human skeletal remains. Repatriation engendered a certain level of urgency related to skeletal analysis of collections because the legislation stated that remains and associated artifacts must be offered for return to tribal representatives in a timely matter. This process limited the amount of time that anthropologists had to spend on the analysis and also prevented re-analysis, because remains were often reburied following repatriation. Even when skeletal assemblages were not immediately reburied, access to collections was often limited due to political, budgetary, and time constraints (Stodder 2012). Additionally, repeated handling of often fragile and fragmentary remains jeopardized preservation, thereby inhibiting future interpretation (Stodder 2012). Due to the limiting effects of repatriation law and repetitive handling, it became necessary that physical anthropology devote additional resources and thought toward data collection, a more stable and permanent resource than human skeletal remains (Stodder 2012). In 1994, *Standards* (Buikstra and Ubelaker 1994) was developed in response to repatriation legislation to minimize the loss of data and maximize comparability of data between institutions across the country (Ousley et al. 2005).

RELATIONAL DATABASE MANAGEMENT AND DESIGN

Relational Database Structure

Following enactment of repatriation legislation, the field of anthropology was not only confronted with issues of data collection and the development of S*tandards*, but also the issue of data curation and preservation. In the summation of a NSF-sponsored workshop on the preservation of archaeological data, Keith Kintigh (2006:567) outlines the need for archaeologists to develop an "information infrastructure that will allow us to archive, access, integrate, and mine disparate datasets." Each year, anthropologists generate large volumes of incompatible digital data. Datasets are created using a wide variety of software, text editors and spreadsheets, as well as information stored in photographic and radiographic archives. The variable nature of data curation, including the vast array of data generated (i.e., osteological, photographic, radiographic, archaeological, ethnographic, etc.) make the task of data integration a formidable endeavor (Keller 2009:26). A well-structured database allows collection and long-term curation of compatible digital data from a variety of sources. Because the data collected under the NMAIA was recorded following *Standards*, in a short period of time, and from variable categories, the ROL designed Osteoware as a relational database. When compared to a "flat file," such as an Excel Spreadsheet, a relational database provides a more efficient way to maintain data quality, transparency, and completeness; promote collaborative interaction; and permit for the database to expand and change as the research project evolves (Nunn 2011). Relational databases do not impose a structure on the data, which hierarchical and traditional databases do. Breaking data into multiple tables also enables a more efficient means of storage, easier data manipulation, and greater scalability as the collection grows. Furthermore, relational databases are often compatible with statistical programs and online software such as ArcGIS, which permits ease of use in future research (Nunn 2011).

Relational databases are usually composed of two or more tables where a unique field in one table is linked to a unique field(s) in another table(s). However, for a database to be relational, it does not require linked data tables (Keller 2009:27). A database with only a single table can, in fact, be relational if it conforms to the relational model as outlined by Edgar F. Codd, the father of modern relational database design (Codd 1970; Keller 2009:27). Codd (1970) developed an efficient and secure model for storing data, the relation in a "relational" database, by combining set theory and information technology. Codd (1970:379) defined the "relation" as a set of values, organized into a matrix of rows and columns, where constraining relationships exist between all values within the matrix based upon position (Keller 2009:28). For a relation to be properly structured, "each row must describe a single entity (such as an artifact) that is uniquely identifiable [and] each cell must contain a single, non-composite value that may not be repeated elsewhere in the same row" (Keller 2009:28). All values within a row of a relation must apply to the same item and all values within a single column must record the same kind of information (Keller 2009:28). In this sense, a significant amount of information about the data (metadata) is captured in the database structure alone.

The unique identifier of each record within a matrix, or primary key, is critical to the function of any relational database containing multiple tables. A primary key is important because it ensures that data values entered into one table are also easily accessible in another linked table (a primary key cannot be null) (Nunn 2011: 302). In short, the primary key provides the scaffolding of the relational database structure and ensures that all entered data can be used, providing a link between multiple tables and ensuring that all data are consistent and correctly linked throughout the database, providing what is known as 'relational integrity' (Nunn 2011:302). It is the relational structure of a database that allows for the application of data mining techniques to large datasets.

Data Accessibility

Data mining is defined as "a computational method for analyzing large quantities of quantitative data in order to discover and extract features within the data that warrant further attention," and is a means of manipulating large datasets (Rogers et al. 2013). Data mining is characterized by three attributes: (1) it automatically makes accurate predictions from data, (2) it has the ability to screen a large number of predictors, and (3) it does not require the user to make any assumptions about the relationships between predictor variables and response data (Hochachka et al. 2007). The main objective of data mining is to identify valid and potentially useful correlations and patterns in a dataset (Chung and Gray 1999). Data mining can work from the bottom-up (explore raw facts to find existing connections) or from the top-down (search the data to test established hypotheses) (Chung and Gray 1999). Because the bottom-up method of data mining goes against traditional scientific method, it provides a promising and unique tool for investigation and data collection because it has the potential to influence the formulation of research questions. This data-driven technique can identify previously unknown patterns, thereby generating questions and hypotheses that otherwise would have remained unidentified. Regardless of the way data mining is accomplished (bottom-up or top-down); it offers tremendous and previously untapped research opportunities. Data mining in itself is multi-disciplinary and incorporates concepts from statisticians, computers scientists, operations researchers, and information systems (Chung and Gray 1999). Data mining tools typically use in-memory data querying principles, such as Structured Query Language (SQL). SQL performs queries in the exact location where data are stored, and is extremely efficient at storing and accessing structured data (Raste 2014). SQL allows the user to retrieve and manipulate data stored a relational database. SQL – and in particular the relational database structure - allows the researcher to search and extract only the information necessary for their analysis, leaving the original data intact. No other system is as flexible.

The relational database utilized at the SI, Osteoware, is a data entry portal (also known as a graphic user interface) that allows limited editorial access to a single record at a time. Each record, however, is stored within the relational database structure, which is accessible through a Relational Database Management System (RDBMS; Dudar 2011a). The RDBMS used in conjunction with Osteoware is the Sybase® Advantage Data Architect™ (henceforth referred to simply as Advantage™) (Dudar 2011a:84). Advantage™ allows for the management, querying and extraction of data from the database. Using SQL, Advantage™ allows easy extraction of meaningful data through the development of complex relationships across multiple tables in the relational database. In other words, SQL statements allow the researcher to combine data from multiple tables, thereby accurately and efficiently narrowing down the focus and producing only the desired data output while omitting undesired information. For example, the researcher can combine data from the AgeSex, CulturalAffiliation, and Pathology tables to search for Arikara males between the ages of 25 and 35 with cranial trauma, thereby narrowing thousands of records down to a more manageable number of less than 100. SQL is further outlined in the methods section.

ARCHIVAL DATABASES IN ANTHROPOLOGY

The SI's digitized osteological collection is one of the largest of its kind, both nationally and internationally. Prior to this research, there was little scholarly discussion concerning the benefits of using the SI collections as an independent source of large-scale, time-space distributional data. Likewise, the field of anthropology has not thoroughly addressed the potential of mining osteological databases.

One of the biggest advantages to using large datasets of digitized data is the potential to expand the scale of bioarchaeological research. An often-cited limitation to increasing the scope of bioarchaeological research is non-comparability of data (Stodder 2012:348). As mentioned, one of the benefits of storing data in a relational database system is that the data collected was standardized. In the past, finding comparable data involved searching the literature for compatibility in data collection methods and in reporting (i.e. raw data, grouped data, descriptive statistics, etc.). With the development of *Standards*, anthropologists took strides towards resolving the issue of data incompatibility. Storing data in a relational database took the resolution a step further by increasing the availability and accessibility of the data collected. However, accessibility is achieved when data can be explored and manipulated through the employment of queries and data mining tools. Therefore, it is imperative that anthropologists learn the skills necessary to extract and manage data.

Osteoware is one example of anthropologists beginning to accumulate standardized datasets that can be used to tackle broad-scale or big picture anthropological research questions. By increasing the scale of analysis from a single sample to include several samples or temporal ranges, and likewise incorporating data from a variety of sources, we are moving closer to understanding the social processes driving osteological manifestations of change. In addition to the development of Osteoware, there are several previous attempts at creating large-scale, time-space distributional databases in anthropology, including, but not limited to, the Global History of Health project database (Steckel et al. 2006) and the Wellcome Osteological Research Database (WORD; White 2008). While each of these databases attempt to generate large-scale digital data repositories of anthropological data, they differ in terms of the types of data recorded as well as the data recording methods. While Osteoware uses data coding protocols based upon *Standards* and records primary osteological data, WORD contains both archaeological and osteological data (recorded with a unique qualitative coding system), and the Global History of Health Project database prompts researchers to enter descriptions of pathologies based on the location, type, healing status, and size of the affected area (Steckel et al. 2006:28). Although we have still not vanquished the issue of non-comparability of data, as a field, we must continue to build standardized digital osteological collections which can serve in large-scale analysis of the past, as well as push toward a better understanding of how to explore, manipulate and integrate these large digitized datasets.

SUMMARY

Ultimately, repatriation legislation led to a number of significant contributions to field of physical anthropology, including: (1) the inventory process is eliminating gaps in our skeletal evidence for past peoples and lifeways, (2) osteological data collection and analyses are now more comprehensive, (3) curation facilities are improving and transitioning into curated digital collections, and, (4) the establishment of large scale databases generated from the osteological data (Rose et al. 1996). The development of large, digital repositories for osteological data allows us to increase the scale of analysis of past human lifeways, expanding our focus from a single population to intra-community studies and analyses that span wide geographic regions and temporal periods. It is unrealistic for a single individual today to collect data from a sample of this size and scope. With the development of standardized datasets, large-scale data-driven approaches to bioarchaeological research become a reality.

CHAPTER 4: THE GREAT PLAINS – LANDSCAPE, ARCHAEOLOGY & HISTORY OF THE REGION

The Great Plains region comprises a vast geographic expanse in the interior of North America. While the region has been extensively studied, documented, and referenced, it has consistently proven somewhat difficult to define (Gill 2008). Physiographers have used landmarks to frame the region, however, boundaries are often unclear, especially on the eastern periphery (Gill 2008:5). Environmentally, the region is characterized by relatively level land, treelessness, and a sub-humid to relatively arid climate (Gill 2008:5). While each of these characteristics can be observed in isolation throughout the United States, it is the convergence of all three environmental characteristics that defines the Great Plains (Gill 2008:5). The region has historically been defined as a vast expanse of grassland most recognizable for the immense herds of bison and the tribes that subsisted on these herds (DeMallie 2001). According to modern geographic boundaries, the region includes Kansas, Nebraska, South Dakota and portions of Montana, Wyoming, North Dakota, Oklahoma, Texas, Colorado, New Mexico, Missouri, Iowa, and Minnesota (Gill 2008: 5). The northern boundary also extends into Canada and includes portions of Manitoba, Saskatchewan and Alberta. Historically, anthropologists have used a combination of environmental and prehistoric cultural traditions to define the region. Human occupation of the North American Great Plains began in the late Pleistocene and the region demonstrated continuous human habitation for the past 11,500 years (Wedel 1986; Wood 1998).

The culture history of the region has been subdivided into five broad periods: Paleo-Indian, Archaic, Woodland, Plains Village, and Historic (Wedel 1986; Wood 1998; Zimmerman 1985). Culture periods are defined by differences in technology, subsistence, settlement patterns and to a lesser extent, social attributes (Wood 1998). While the culture periods are sequential, there are no set temporal or spatial criteria that separate them (Wood 1998). In general, the Paleo-Indian period is characterized by highly mobile bands of hunters and gatherers roaming the region in pursuit of bison. Throughout the Archaic period, nomadic foragers became adapted to their local environments, thereby limiting their geographic ranges. Woodland populations began to develop horticulture, incorporating corn, beans and squash into their diets, and as they became increasingly sedentary, crops became a dietary staple. The Woodland period transitioned into the Plains Village period, which was marked by full-scale sedentary village life. Temporally, the Plains region is divided into the Hunting and Gathering tradition represented by the nomadic tribes of the High Plains (8000 B.C. until the early 19th century); the Plains Woodland tradition observed on the eastern edge of the region (500 B.C. to A.D. 1000); and various Village traditions represented by the semi-sedentary village tribes of the Missouri River Valley (roughly A.D. 700 until the 19th century) (DeMallie 2001).

Geographically, the region is subdivided into three distinct subareas: the Northern, Central, and Southern Plains (Blakeslee 1994:12). The Northern Plains subarea has three distinct regions: the Middle Missouri, Northwestern Plains, and Northeastern Periphery. This research focuses on the Middle Missouri, a region ranging from the trench of the Missouri River from the Nebraska-South Dakota border to the North Dakota-Montana border (Blakeslee 1994:12). The Mandan, Hidatsa, and Arikara inhabited the Middle Missouri region and participated in the Plains Village lifestyle during the prehistoric, protohistoric, and early historic periods (Johnson 2007).

ARCHAEOLOGICAL TAXONOMY

Before the sample can be introduced and the tribe presented in a chronological framework, a brief introduction to archaeological taxonomy and terminology is necessary. The terms pattern, phase, tradition and variant are used to group archaeological sites based on similarities in artifact types, lifeways, geography, and time (Figure 1; Billeck et al. 2005: 15). A phase is the smallest unit and is represented by a series of similar cultural traits that are restricted in both space and time (Willey and Philips 1958). Phases typically last less than one hundred years and are circumscribed in a specific geographic region. Several contiguous phases form a tradition. Traditions span longer temporal periods and wider geographic ranges. A variant falls between phase and tradition on the taxonomic scale and refers to a unique cultural tradition that can be distinguished from other variants of the same tradition based upon differences in geographic distribution, age, and/or cultural traits (Lehmer 1971:32).

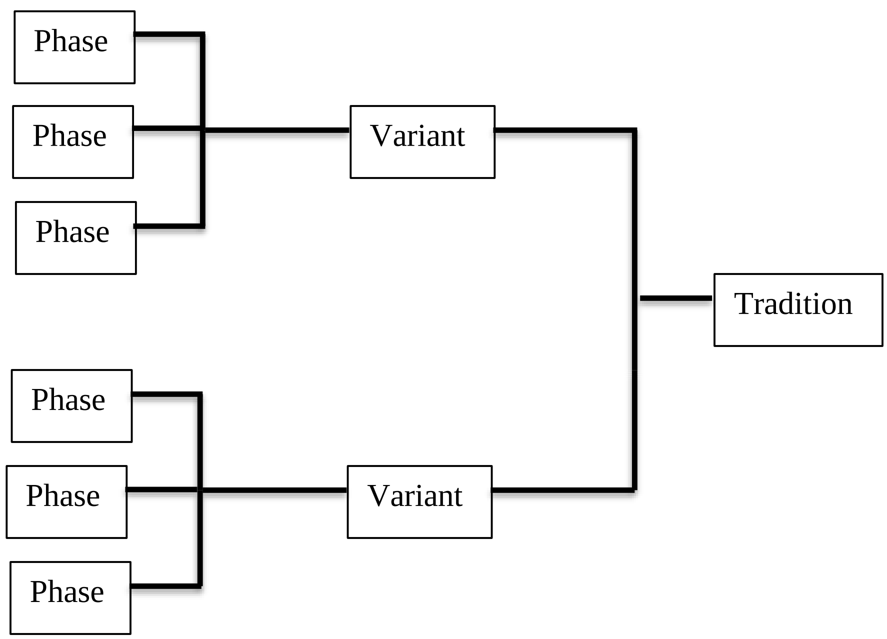

Figure 1. Archaeological Taxonomy Showing the Hierarchy of Phases, Variants and Traditions (Figure 3; Billeck et al. 2005:17)

It has been suggested that all aboriginal villages of the Northern Plains represent a single basic cultural configuration, the Plains Village Pattern (Lehmer 1971:27). According to Lehmer (1971:27), the diagnostic traits associated with the Plains Village Pattern include:

> "subsistence based about equally on hunting and agriculture; semi-permanent villages located close to the floodplains of the larger streams; earthlodges with enclosed entryways; undercut and straight-sided cache pits in and between houses; grit-tempered pottery, usually having paddle-marked bodies and cord- or tool-impressed decoration; large numbers of chipped stone tools including snubnose scrapers and small, light projectile points; numerous hoes made from bison scapulae; and a wide variety of bone artifacts, including several kinds of hide-dressing tools."

There are three traditions within the Plains Village pattern in the Middle Missouri River Valley: Central Plains, Middle Missouri, and Coalescent (Lehmer 1971:27). The Central Plains tradition (A.D. 1100 - 1400) is culturally affiliated with the Pawnee, Arikara and Wichita (Billeck et al. 1995:17). The Middle Missouri tradition (A.D. 1000 - 1650) is most likely culturally affiliated with the Mandan, while the Coalescent tradition (A.D. 1300 - 1886) is, at least in part, affiliated with the Arikara tribe (Billeck and Byrd 1996; Billeck et al. 2005:17). Sites associated with the Coalescent tradition also represent the prehistoric and historic Mandan, Hidatsa, Pawnee, Cheyenne, and Ponca (Johnson 1998:399). The Coalescent tradition consists of three continuous variants: Initial, Extended, and Post-Contact (Table 1). The Initial Coalescent dates approximately A.D. 1300 to 1500 (Billeck et al. 2005:19). The Extended Coalescent tradition spans A.D. 1500 to 1650, and the Post-Contact Coalescent dates approximately A.D. 1650 to 1886 (Ahler et al. 1995; Billeck et al. 2005; Lehmer 1971; Toom 1996). Initially, it was conceived that the Coalescent tradition should be divided into four variants. The fourth variant was the Disorganized Coalescent that dates approximately A.D. 1780 to 1862 and represented the historic populations just before the establishment of reservations (Lehmer 1971). Blakeslee (1994) treats the Post-Contact variant as the beginning of the Historic period, while Johnson

(1998) includes historic sites, such as Leavenworth (39CO9), in the Post-Contact variant of the Coalescent tradition. This research includes Leavenworth with the Post-Contact Coalescent tradition.

Table 1. The Coalescent Tradition and Variants with Approximate Dates

Tradition	Dates
Initial Coalescent	A.D. 1400 - 1550 (Lehmer 1971:33)
	A.D. 1300 - 1500 (Toom 1996:69)
	A.D. 1300 - 1600 (Johnson 1998:313)
Extended Coalescent	A.D. 1550 - 1675 (Lehmer 1971:33)
	A.D. 1500 - 1650 (Toom 1996:69)
	A.D. 1400/1450 - 1650 (Johnson 1998:318)
Post-Contact Coalescent	A.D. 1675 - 1780 (Lehmer 1971:33)
	A.D. 1650 - 1886 (Toom 1996:69)
	A.D. 1600 - 1862 (Johnson 1998:320)
Disorganized Coalescent	A.D. 1780 - 1862 (Lehmer 1971:33)

Initial Middle Missouri variants were the first village cultures to appear in the Middle Missouri subarea. The two variants share a substantial number of traits, suggesting that they represent the same cultural configuration with differences resulting from geographic distribution, age, and form of traits (Lehmer 1971:65). Culture history of the Middle Missouri subarea changed greatly at the beginning of the 15th century. Before this time, the region was occupied solely by the Middle Missouri Tradition (Lehmer 1971:107). Shortly after A.D. 1400, the population responsible for the Initial Coalescent tradition arrived in the southern portions of the Middle Missouri subarea (Lehmer 1971:125). Similarities in house structure, pottery, and other artifacts suggest that Initial Coalescent tradition people were immigrants from the Central Plains (Lehmer 1971:125). The Central Plains tradition occurred in the westernmost portion of Iowa, eastern and south-central Nebraska, and Kansas north of the Arkansas River drainage (Lehmer 1971:107). The tradition existed between A.D. 900 and 1500 and appeared to be contemporaneous with the Initial and Extended Middle Missouri variants in the Middle Missouri River Valley. Originally, the Initial Coalescent variant was hypothesized to represent the first stage of the blending of two traditions, the Middle Missouri tradition and the Central Plains tradition (Lehmer 1971:111). Now, the Initial Coalescent tradition is thought to have resulted from a diffusion of Central Plains traits into the Middle Missouri Valley because in its original form the variant is indistinguishable, in most respects, from the Central Plains tradition (Johnson 1998:308). It has been suggested that this massive migration into the Missouri River valley was the result of drought conditions in the Central Plains (Lehmer 1917:115). Three distinct cultures inhabited the Big Bend and Bad-Cheyenne regions during the late 15th and early 16th centuries, the Initial Coalescent, Modified Initial Middle Missouri and Extended Middle Missouri (Lehmer 1971:125). Occupation of the region by Middle Missouri tradition people likely ended around A.D. 1550 because of pressures from the Initial Coalescent people (Lehmer 1971:126). As the Middle Missouri tradition was pushed from the region, the Initial Coalescent tradition expanded northward and changed into the Extended Coalescent variant (Lehmer 1971:126). The Extended Coalescent traditions is thought to be a direct outgrowth of the Initial Coalescent tradition, with slight differences resulting from the modification and expansion of the Initial Coalescent culture (Lehmer 1971:115). The Extended Coalescent tradition also differed from the Initial Coalescent because the tradition is marked by a rapid geographic expansion of villages throughout the Middle Missouri River Valley. Extended Coalescent sites are widely distributed geographically between the North-South Dakota border and the White River (Lehmer 1971:115).

In summary, sometime between A.D. 1400 and 1675, there was a massive migration of Central Plains populations into the Middle Missouri Valley, which developed into the Initial Coalescent tradition. As the Initial Coalescent tradition expanded, Middle Missouri groups withdrew from the southern regions and the Initial Coalescent groups moved north, nearly to the North-South Dakota border (Lehmer 1971). Subsequently, the geographic distribution of the two cultures began to stabilize and the Coalescent culture occupied the Missouri River Valley in South Dakota, while the Terminal Middle Missouri groups occupied the Upper Cannonball and Knife-Heart regions of North Dakota (Lehmer 1971).

ARIKARA

The Native American tribe emphasized in this research is the Arikara. While the 21st century Arikara formed a single tribal entity, tracing the lineage back into the 18th century reveals an aggregate of Caddoan-speaking bands and villages (Parks 2001). The Arikara comprise the northernmost member of the Caddoan language family and the group is thought to have diverged from the Pawnee after A.D. 1400 (Rogers 1990). Ancestors of both the Arikara and the Pawnee have been traced to the Upper Republican phase of the Central Plains tradition (Parks 2001).

Historically, the Arikara were a farming tribe, inhabiting earthlodge villages throughout the Missouri Valley (Billeck et al. 2005). Agricultural settlements developed in the fertile river bottom where the tribe grew corn, beans and squash. In addition to their horticultural practice, Arikara subsistence economy was largely dependent upon bison hunting. Earthlodge villages were typically occupied from spring through the middle of summer. After the corn was planted in mid-summer, the tribe typically left the village for a time to participate in an extended bison hunt on the prairie (Billeck et al. 2005:4). Villages were then re-occupied as the harvest approached and were likely continuously inhabited throughout the winter.

During the 18th century, the land occupied by the Arikara tribe was on the edge of European knowledge. Therefore, few direct references can be found in the literature. The first recorded direct contact between a European and the tribe was in 1743, when Chevalier de La Vendrye visited an Arikara settlement (Smith 1980:112). While direct European contact was infrequent in the 18th century, historical records of European contact were also recorded by Truteau in 1794-1795, Mackay-Evans in 1796-1797, Tabeau in 1804-1805, and Lewis and Clark in 1804-1806 (Figure 2). Throughout the 18th century, the majority of European contact with the tribe was indirect and involved contact through the exchange of Euro-American goods through the vast trade network. Both French and Spanish traders traveled northward up the Missouri River, however, the majority of direct trade terminated in Nebraska with the Omaha and Ponca tribes (Billeck et al. 2005:5). European references to the Arikara tribe in the 18th century report the tribe living along the Missouri River in South Dakota (Billeck et al. 2005). The Arikara resided in South Dakota until the 1830s when they migrated north into North Dakota (Billeck et al. 2005:4).

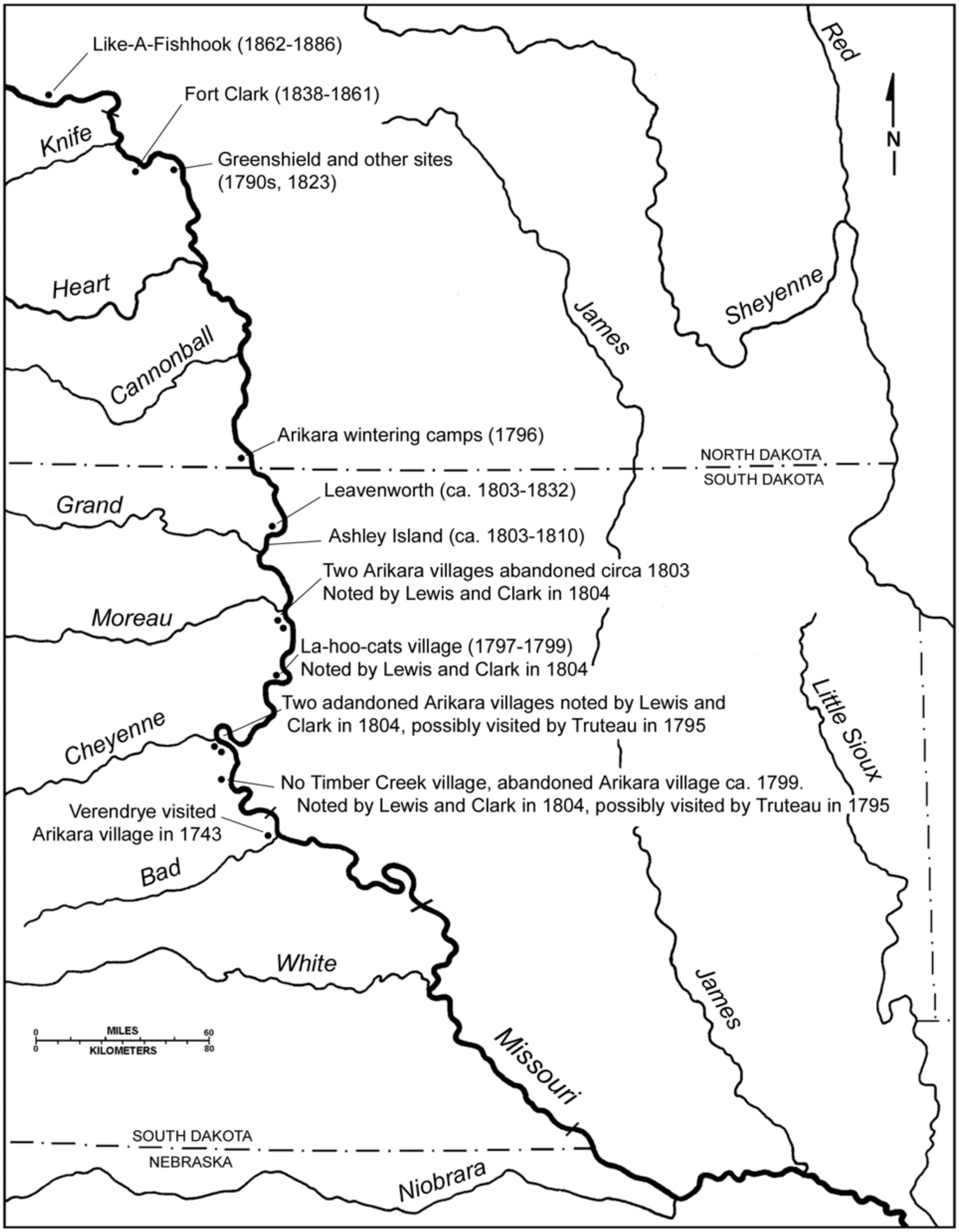

Figure 2. Map of Arikara Occupations as Reported by Euro-American Traders and Explorers in the 18th and 19th Centuries (Figure 2; Billeck et al. 2005:8)

Historic records indicate a rapid decrease in Arikara populations in the 18th and 19th centuries. In a report by Bourgmond written in 1714, the trader mentions two contiguous Arikara villages lying north of Omaha in present-day Nebraska and another 40 villages of "Caricara" higher up the Missouri River (Billeck at al. 2005:5; Norall 1988:110). The number of villages and population size rapidly diminished as a result of disease and warfare. The Arikara were particularly susceptible to disease because their involvement in the fur trade put them in direct contact with carriers of infectious diseases, such as smallpox, against which they had no conferred immunity. Because the tribe was primarily horticultural, with individuals living in multi-family dwellings, the dissemination of infectious disease was rampant. Decimation of Native American populations due to the spread of epidemic disease stands out as one of the most significant impacts of early contact (McGinnis 1990).

The integration of the horse and gun into Native American life following European contact also resulted in a tremendous amount of cultural change for the tribe. It is impossible to specify an exact date for the contact period in the Plains, primarily because European excursions into the region were widely separated both geographically and temporally at the northern and southern reaches of the territory (Lehmer 2001). Participation in the trade network and attainment of the horse and gun facilitated hunting and access to European goods (Wedel 1972). However, this period of cultural climax was short-lived. Both the ethnohistoric and archaeological records indicate an eastward retreat of Plains village groups as highly mobile bison hunters began to dominate the Western and Central Plains, outcompeting the horticulturalists for food and access to trade goods (Wedel 1972). Mass displacement of village populations shifted the balance of power in favor of the nomads for two reasons: (1) the horse-mounted nomads were able to exploit the more distant and migratory bison herds, and (2) the village peoples were more susceptible to epidemics (Calloway 1982; Hanson 1998). The Arikara, once 43 villages strong, were depleted to only two villages by 1790 and the survivors were forced to move north, away from the path of the Sioux migration (Calloway 1982). Plains tribes were faced with serious consequences of white settlement, including near-complete depletion of the bison herds, spread of epidemic disease, warfare with both European-American and Native American neighbors, and finally confinement on reservations (Fowler 2001). Both hunters and farmers underwent cultural attrition as white contact increased and the reservation destroyed what was left of Native social institutions and traditions (Fowler 2001; Wedel 1972).

Following smallpox epidemics in 1792, 1836 and 1837, the Arikara, Mandan, and Hidatsa tribes had so few surviving members that they were forced to establish a single society at Like-a-Fishhook Village, to maintain cultural continuity (Schneider 2001). The Arikara tribe in the 21st century is one of the Three Affiliated Tribes, also known as the Mandan, Hidatsa, and Arikara Nation (MHA Nation 2016). The Three Affiliated Tribes settled on the Berthold Indian Reservation in New Town, North Dakota, in 1936 (Schneider 2001). The reservation now represents a small portion of the land reserved for the tribe in the Fort Laramie Treaty of 1851 (Parks 2001:367)).

WARFARE ON THE PLAINS

Documentation of violence on the Plains, showed a considerable time depth, ranging from circa A.D. 900 through the historic period (Blakeslee 1994: 24-25; Owsley 1994). While violence was present throughout the region, the level of warfare on the Southern Plains never reached the pervasive and regional intensity documented in the Northern Plains (Brooks 1994). Warfare in the Southern Plains was restricted to frontier areas in the form of small-scale hostilities resulting from competition for resources and border control (Ubelaker 1994). In the Northern Plains, warfare was so extensive and institutionalized that Robarchek (1994) considered it a long-standing cultural tradition. The archaeological record clearly demonstrated that violence in the Northern Plains was not simply an opportunistic behavior practiced generation after generation (Robarchek 1994). According to Robarchek (1994:312), violence was "in short, a regional cultural institution, a complex of values, ideas and behaviors that persisted for at least two thousand years." Violence among and between Native American groups did not begin with European contact. Instead, violence predated the waves of migration, competition for horses, and disagreements related to trade, all of which were initiated by first contact (Robarchek 1994).

At various times during the historic period, the Arikara participated in internecine warfare with Assiniboine, Crow, Mandan, Hidatsa, and, particularly, the Sioux (Owsley, Berryman, and Bass 1977). Such inter-tribal hostilities likely existed during the prehistoric period as well. Intertribal aggression between tribes was usually small-scale, with raids involving only a few warriors whose objectives were to steal horses or avenge grievances. The Arikara's position as middlemen in the trade network, along with their agricultural lifestyle, also made them a frequent target of inter-tribal raiding (Owsley 1994). A study by Owsley (1994) provides evidence that small-scale warfare was fairly common during all variants of the Coalescent tradition on the Northern Plains. On occasion, large-scale warfare occurred when military units of several hundred warriors gathered to attack a village (Owsley 1994:334). Several examples of large-scale warfare include Larson, Fay Tolton, and Crow Creek sites. The pattern of raids and intermittent warfare is an enduring characteristic of social interaction on the Northern Plains that is thought to have persisted through the prehistoric period. This pattern of violence probably did not change dramatically throughout the protohistoric and early historic period (Owsley 1994).

It has been suggested that throughout most of the historic period of intertribal warfare, Native American women were more likely to be taken captive than killed (Ewers 1994). Early in the historic period, women captives were used as pawns in the intertribal trading system, passing west to east and often ending up in trader outposts (Ewers 1994:326). However, it must be noted that the Assiniboine, Blackfeet, Sioux, Cree, and Arikara were known to kill women and children, and celebrate those scalps as much as their male counterparts (Denig 1930:552). There is also ample ethnographic and historic evidence of women actively engaged in combat (Ewers 1994).

Warfare played a significant role in Plains Indian life, and women's roles were both passive and active (De Pauw 2000; Ewers 1994). In 1832, George Catlin wrote about a war story told to him by a Mandan Chief, Four Bears (Ewers 1994). The chief spoke of avenging a murder of one of his tribesmen and how he penetrated a village and killed two women in full view of the tribe (Catlin 1975:154 as cited in Ewers 1994:325). Although his victims were women, the murder was avenged, and he was entitled a victory to his credit. Interestingly, there is an earlier reference to the transition from killing and scalping women, to taking enemy women captive during the historic period (Ewers 1994:325).

Members of the Piegan tribe believed that women had to be saved and adopted into their village to bolster their population in strength and number (Ewers 1994:326). However, the killing of enemy women persisted in Plains warfare throughout the nineteenth century (Ewers 1994:326). Preference for the killing or capture of enemy women appeared to have been dictated by tribal affiliation and location.

Despite the risk of death, scalping and capture, the ethnographic literature proved that not all women were content to stay home and pray for their warrior's homecoming (Ewers 1994:328). In 1751, the governor of New France wrote in a letter to the French minister that the Comanche and Wichita tribes take their women into battle with them (La Jonquire 1908:88 cited in Ewers 1994:328). Literature dating to the 1860s and 1870s provided ample evidence of Native American women fighting alongside men against the United States Army (Powell 1981, 2:964 cited in Ewers 1994:328).

While it has been demonstrated that intertribal conflict has a long-standing history in the Great Plains, sustained contact with Europeans is thought to have led to fluctuations in the intensity and practice of warfare. Levels of intertribal violence and warfare waxed and waned as Plains' inhabitants witnessed tremendous changes in Native power structures with the introduction of the horse and the gun (Calloway 1982). The horse is claimed to have increased war casualties, led to smaller war parties, and brought about the disappearance of war chiefs among Native American tribes (Driver 1961). Before contact, nomadic tribes competed with village tribes for access to bison-rich hunting grounds. The horse increased this competition, and after tribes began to assimilate horses into their cultural practices, Europeans introduced guns (Calloway 1982). Guns and horses were the decisive factors in determining a tribe's success in warfare and the tactics of warfare were altered with the stealing of a horse becoming comparable to counting coup (Calloway 1982; Driver 1961; McGinnis 1990).

Explanations for Plains warfare are drawn primarily from historic, ethnohistoric, and ethnographic data (Brooks 1994). It is more difficult to reconstruct the causes of warfare in the prehistoric period than the historic because this period lacks written historic and ethnographic data. However, archaeology and oral accounts can be used to reconstruct the conflict setting.

Archaeology reveals the construction of dwellings and villages as well as yields evidence of fortification and other defensive architecture. Spatial distribution and demographic information must also be taken into account in any analysis of violence in prehistory, because these indicators are suggestive of the scale of conflict (i.e., raids versus warfare). Interpersonal interactions and explanations of warfare can also be derived from Native American oral histories. Echo-Hawk suggests that "academic constructions of ancient human history can benefit substantially from the study of verbal records created and handed down from first hand observers" (2000: 286). Echo-Hawk demonstrates that Arikara narratives provide a summary of human history in the New World from initial settlement throughout the historic period.

Tied to the study of human violence is a thorough analysis of skeletal trauma and accurate interpretation of osteological data. Bioarchaeological evidence includes traumatic injury patterns, including fractures, blunt and sharp force trauma, embedded projectile points, and cut marks suggestive of scalping, mutilation or dismemberment (Brooks 1994). One of the most challenging aspects of evaluating skeletal trauma is determining the etiology of the injury. There are many social and/or cultural reasons why an individual, or multiple individuals, would incur skeletal injuries. Reasons for skeletal injury include inter-tribal interactions such as military or warfare involvement, intra-tribal or domestic violence within the village, accidental or occupational injuries, etc. (Filer 1997). Distinguishing between different causes and mechanisms of injury is one of the primary difficulties faced by bioarchaeologists (Jurmain 1999).

In addition to providing information pertaining to violent interactions, trauma analysis can make significant contributions to the interpretation of interpersonal relationships, lifestyle, environmental stressors, political structure, and accidental injury. In summary, a detailed analysis of traumatic injury can yield information about life at the individual, as well as the population, level. As the field of anthropology evolves, the role of the bioarchaeologist is destined to change, and trauma analysis must change into a more technologically driven process. One of the best means of utilizing recent technological innovations is to employ data mining techniques to explore and improve our understanding of past human populations using the large-scale osteological repositories built by our predecessors in the field.

CHAPTER 5: RESEARCH QUESTIONS & EXPECTATIONS

This dissertation tests the hypothesis that data previously recorded from SI repatriation collections can be used to conduct high quality, holistic bioarchaeological research. Testing this hypothesis is achieved through the extraction of osteological data from the SI digital relational database and the integration of osteological data with photographic and radiographic data, ethnographic, ethnohistoric, archaeological collections. The impetus for the present research, therefore, was enactment of the NMAIA in 1989 and the development of *Standards* for the collection and curation of large digital osteological datasets.

RESEARCH QUESTIONS AND EXPECTATIONS

Primary Research Questions

This research will address a number of broadly defined research questions pertaining to the functionality and usability of the Smithsonian osteological database, Osteoware, and RDBMS, Advantage^{TM}.

QUESTION 1: Is the Smithsonian's digital osteological database amenable to original research pertaining to traumatic injury patterns on the Plains?

This question constitutes the foundation of my dissertation research and it addresses the issue of whether standardized databases are accessible and usable for original research. Although large digital repositories have been built from the data collected from anthropology collections, there has been little effort (or time) to determine whether these databases can be used to address original research questions. To date, scholars have used such databases for comparative purposes, but not as a primary focus of research. In order to address my first research question, I apply data mining techniques to extract and manipulate the osteological data. The data-mining tool applied is Structured Query Language (SQL). SQL performs queries in the exact location that data is stored and is extremely efficient at storing and accessing structured data (Raste 2014). SQL allows for an effective and efficient evaluation of the Smithsonian's relational database storage system. My first research question is primarily qualitative and promoted exploration of the SI osteological data.

QUESTION 2: Is the SI relational database amenable to holistic approaches to bioarchaeological research questions?

The SI database provides a unique opportunity to test theories of interpersonal violence because the repository contains a sample that spans both space and time, is represented in large number, and is associated with ethnographic references and cultural artifacts. The study of violence in the past should take a holistic approach, incorporating multiple lines of evidence, and contextualizing the skeletal observations. A more inclusive approach to the interpretation of interpersonal violence adds to the larger theoretical structure of socio-cultural interpretation (Ferguson 1997: 343). It is only after skeletal trauma is contextualized and addressed from multiple perspectives that it becomes a study of interpersonal violence. The second research question evaluates whether the SI database is amenable to a holistic, bioarchaeological approach.

Traditionally, bioarchaeology attempts to extract meaning from the study of the dead by applying a multi-faceted mode of inquiry (Martin et al. 2013:5). A bioarchaeological approach starts with a question that can be answered with the available empirical data, follows ethical guidelines, includes systematic, rigorous, replicable, and scientifically sound data from human remains, and must include detailed mortuary and funerary data, when available (Martin et al. 2013:5). Bioarchaeological research must also link interpretations of the skeletal remains and mortuary data to broader theoretical issues concerning human behavior.

In addition to integrating osteological data with the mortuary record, bioarchaeologists have argued that the patterning and/or positioning of injuries across the skeleton are indicative of the type(s) of violence which occurred (Ferguson, 1997; Walker, 2001; Lovell,2008). For example, as Walker (2001) and Ferguson (1997) state, stone arrows or lances embedded in skeletal remains almost certainly indicate violence. A more ambiguous example is a parry fracture (fracture of the medial ulna) which is often thought to represent inter-personal violence; as the name of the fracture suggests, the individual with the trauma was likely protecting (parrying) his/her head from a blow by raising an arm (Ferguson, 1997). However, even a parry fracture does not explicitly indicate the mechanism and context of the trauma. Walker (2001) and Jurmain (1999) argue for a population-level approach rather than an individual (or case study) approach for interpreting skeletal trauma. This emphasis on the population is one of the key tenants of the field of bioarchaeology (Larsen, 1997). An individual's injuries may be open to numerous explanations, but when frequencies and patterns of injuries are assessed for a population, some explanations for this individual's injuries become improbable (Walker 2001: 578-9). In addition to the population-level approach to violence, temporally and regionally specific approaches must be taken. In this way, the more contextual information that is acquired, the higher the probability of deducing the most accurate explanation for the skeletal injuries (Walker, 2001, p. 579). Generalized theories of war are highly problematic as they ignore the social and biological differences between cultures across time and space.

While the actual proximate and ultimate cause of traumatic injury may never be known, the following standards of data collection must be followed: a quantifiable description based on specific terminology, photographic and radiographic images of fracture/injuries, the skeletal pattern of trauma in the individual and the population, and the social, culture historical, and/or environmental context of the human remains. The second research questions address whether a holistic interpretation of violence, incorporating osteological data, ethnographic references, and cultural artifacts be achieved through utilization of the SI database?

Secondary Research Questions

This research also addressed a number of more anthropologically oriented research questions. The more specific questions act as a test of the usability of the SI database for original research. These questions are based upon long-standing hypotheses regarding interpersonal violence in past populations, as predicted by anthropological theory. Using the Arikara as an example, traumatic injury patterns are assessed from ten sites dating to the Extended Coalescent and Post-Contact Coalescent variants.

QUESTION 3: Is there a disparity in the patterns of traumatic injury by sex or age?

Social stratification in Arikara society was indicated by a highly gendered division of labor, with women practicing the village functions, such as childcare, food and hide preparation, planting, harvesting, etc.; men focused on the hunt, rituals and warfare (Hollimon 2000:27). In the past, the majority of work pertaining to historic violence focused on male activities, particularly male involvement in warfare (Martin 1997:45). Few studies considered sex-related patterns of violence, and fewer still contextualized violence within a broader socio-cultural framework. The present research is unique because the sample allows for assessment of the differences in the patterns of traumatic injury by sex and age across a broad geographic region and temporal expanse. The patterns observed are compared to ethnographic references to assess the accuracy of bias inherent in ethnographies.

QUESTION 4: Are there differences in the patterns of traumatic injury through time and across space?

The bioarchaeological and historical literature discuss the changing pattern of violent interaction on the Great Plains at the time of European contact (Calloway 1982; Driver 1961; McGinnis 1990). Of particular interest in this research is the question of how European contact affected patterns of traumatic injuries.

The archaeological record demonstrates that violence on the Plains was not simply an opportunistic behavior practiced generation after generation (Robarchek 1994). Instead, violence is reflected as a persistent tradition, or cultural complex, indicating the cultural significance of raiding, scalp taking, and warfare within Native American culture. However, on European contact, Native American groups underwent a series of cultural changes, exacerbated by the introduction of the horse and the gun. With the introduction of the horse, the dynamics of warfare changed. As documented in a number of Great Plains ethnographies, the horse increased war casualties, led to smaller war parties, and brought about the disappearance of war chiefs among Native American tribes (Driver 1961; Calloway 1982). At contact, nomadic tribes were competing with village tribes for access to bison-rich hunting grounds. The horse increased this competition, and shortly after tribes began to assimilate horses into their cultural practices, the Europeans introduced guns (Calloway 1982). Guns and horses were decisive factors in determining a tribe’s success in warfare (Calloway 1982; Driver 1961; McGinnis 1990). Because the SI sample spans the prehistoric throughout the historic periods, this research addresses the issue of whether, as researchers, we are able to identify changes in traumatic injury patterns attributable to European contact. This is accomplished by comparison of trauma patterns between the Pre-Contact sample and the Post-Contact sample. Specifically, I test whether the frequency of traumatic injuries by body region varies between the two temporal periods. A separate analysis of the differences between two contiguous regions of the Missouri River Basin will likely mirror the temporal analysis because the Arikara tribe moved northward through the Middle Missouri River Valley during the protohistoric and historic period (Billeck et al. 2005:40).

QUESTION 5: Do different patterns of injury emerge when the SI osteological data is assessed at different levels of analysis (i.e. village, tribe, between tribes in the Missouri River Basin)?

The SI digital data repository allows a unique opportunity to assess violent human interaction at a number of different levels within a bioarchaeological context. The SI database consists of data drawn from more than 18,000 Native American human remains, over 1000 individuals belonging to the Arikara tribe.

The Arikara sample is one of the largest in the SI anthropology collections and provides a large-scale, time-space distributional data set. The sample used in this research is representative of 10 archaeological sites located in the Middle Missouri River Basin. The ten sites span the Extended Coalescent through the Post-Contact Coalescent periods (approximately A.D. 1300 to 1832). Because of the nature of the sample, this study explores how changing the scale of analysis in bioarchaeological research can affect our interpretations of past populations. In this research, trauma will be assessed at the level of the individual, the population (single site), and between sites. This research will also assess whether the patterned injuries observed in the Arikara sample are comparable to the pattern of injury observed in a second Native American tribe, the Sioux. Is there variability in patterned injury when the SI collection is studied at different levels of analysis or do we see the same injury patterns at the level of the village, tribe, and region? Using a time-space distributional data set, it is hypothesized that bioarchaeologists can get a better understanding of past people and their interpersonal relationship by examining not only a single population, but also comparing populations from different temporal periods and geographic regions.

CHAPTER 6: MATERIALS

As mentioned previously, a need for a computerized database to store and manage data curated by the SI became a necessity with the enactment of the NMAIA (Dudar et al. 2011). For the SI, repatriation legislation required that over 18,000 catalogue numbers for human remains be inventoried and documented, and the data had to be collected quickly. The SI's ROL was established in 1991 and efforts to create a database to manage the massive amounts of data that were being generated by the documentation process began shortly after (Dudar et al. 2011). The original storage repository was a DOS-based Paradox system with text screens and a flat file, non-relational database (Dudar et al. 2011). In 1998, Dr. Stephan D. Ousley, newly- appointed director of the ROL, transitioned the Osteoware software into the first Windows-based data entry program for the lab. Currently, Osteoware uses a RDBMS, where links across data tables are established by a unique identifier or primary key, allowing extraction of data using SQL (Dudar et al. 2011). The Osteoware software program was designed to provide an easy-to-use interface for the entry of both qualitative and quantitative observations of human skeletal remains in a SQL database (Dudar et al. 2011:2). Osteoware works in conjunction with a separate database manager, Advantage Data Architect™ version 9.1 by Sybase Inc., which locates and extracts specific information from the database (Dudar et al. 2011). Osteoware is an institution-wide software program used by the SI and is also available to the public. Both the SI RDBMS and the publicly available versions are identical, and protocols for data recording are based on Buikstra and Ubelaker's 1994 *Standards for Data Collection from Human Skeletal Remains*. The data collected through Osteoware represent a large-scale collection of osteological data ranging from the prehistoric through the historic period. Financial support for the web distribution of the

Osteoware software was provided by grants from the National Center for Preservation Technology and Training (No. MT-2210-10-NC-02), National Park Service, U.S. Department of the Interior, and SI Web 2.0 Fund, Washington D.C. (Wilczak and Dudar 2011).

OSTEOWARE

The Osteoware program is primarily based upon the protocols outlined in *Standards*, however, Ousley and osteologists working in the ROL at the time of program development, made modifications (Wilczak and Dudar 2011). All modifications from *Standards* are outlined in the Osteoware Software Manual. The Osteoware software is also available for public use and can be downloaded from the Osteoware website (https://osteoware.si.edu/). Software manuals are also available on the Osteoware website and can be referenced in the following discussions of Osteoware's format and usage.

Osteoware Format

Before a detailed description of the research methodology can be presented, it is necessary to discuss how data is input through Osteoware. In Osteoware there are a total of 12 Modules: Inventory, Age and Sex, Pathology, Taphonomy, Postcranial Metrics, Dental Inventory/Deviation/Pathology, Dental Morphology, Cranial Nonmetrics, Macromorphoscopics, Cranial Deformation, Craniometrics, and Summary Paragraph (Figure 3). Each module represents a data entry form for a specific skeletal attribute. The modules provide a graphic user interface (GUI), where the analyst uses a series of radio buttons and text boxes to enter quantitative and qualitative information following skeletal analysis. In addition to the 12 modules, there are also two special function buttons: photo request and X-ray request. While the special function buttons can be used to request a photo or X-ray of a specimen, the photos are xrays are not stored in the relational database and cannot be extracted from the program using Advantage™. The module of primary interest in the present research is the Pathology Module. A separate user manual, Osteoware Software Manual Volume II: Pathology Module, is available on the Osteoware website. Because the Pathology Module was the primary focus of this research, an in-depth discussion of the Module and its usage will be provided here.

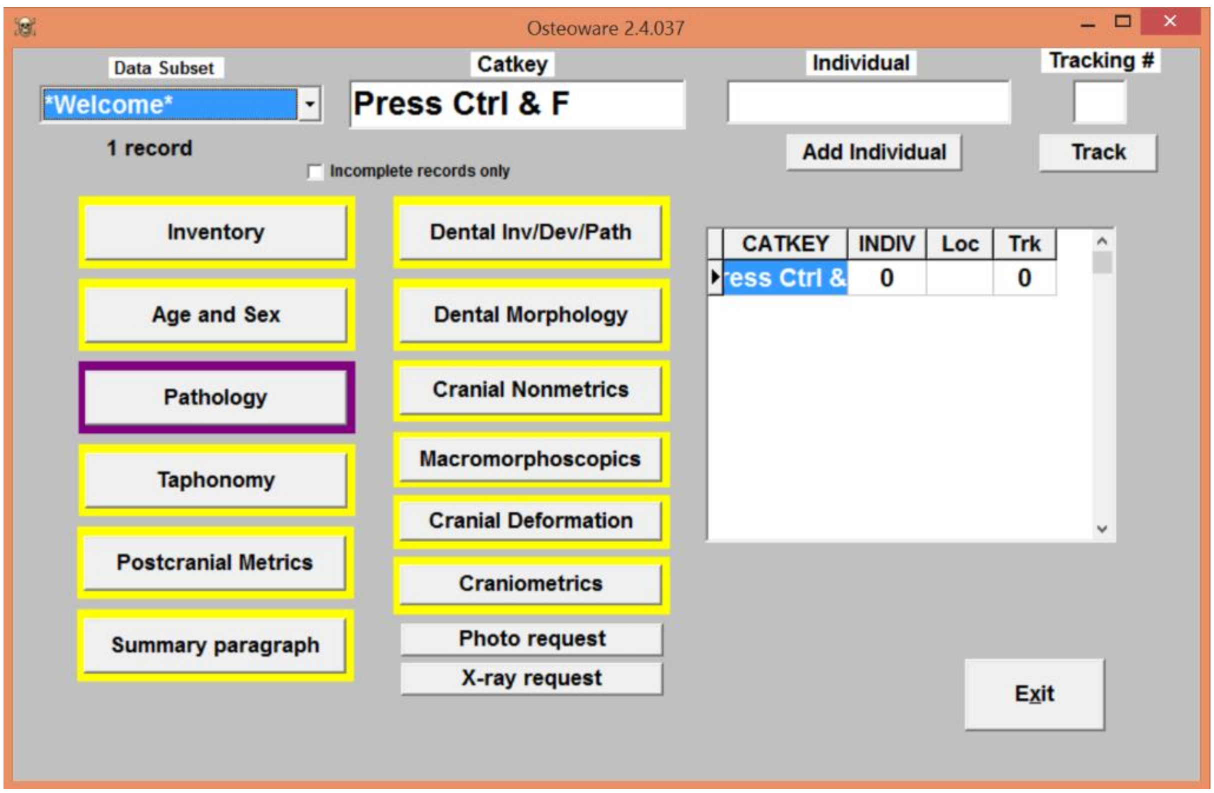

Figure 3. Osteoware Home Screen (modules are outlined in yellow)

Pathology Module

Recording of pathological changes is one of the most complex of all skeletal analyses. Consequently, there are a larger number of data entry screens in the Pathology Module than in other modules in the Osteoware program (Wilczak and Jones 2011). The Pathology Module also incorporates more modifications from the traditional *Standards* than any other module (Wilczak and Jones 2011). The main objective in designing the Osteoware Pathology Module was to "provide an intuitive graphic user interface (GUI) and flexible framework for categorizing and documenting complex pathological observations into Structured Query Language (SQL) database, thus allowing for subsequent analyses within and between skeletal samples" (Dudar 2011b:4). The Pathology Module has the following data-entry screens: Side/Aspect/Section, Bone Loss, Trauma, Abnormal Bone Formation, Size/Shape/Bone Specific Abnormality, Porosis/Vascular Channel, and Arthritis (Figure 4). Of all the data recorded in the Pathology Module, the information with the greatest value to this research is drawn from the Trauma section.

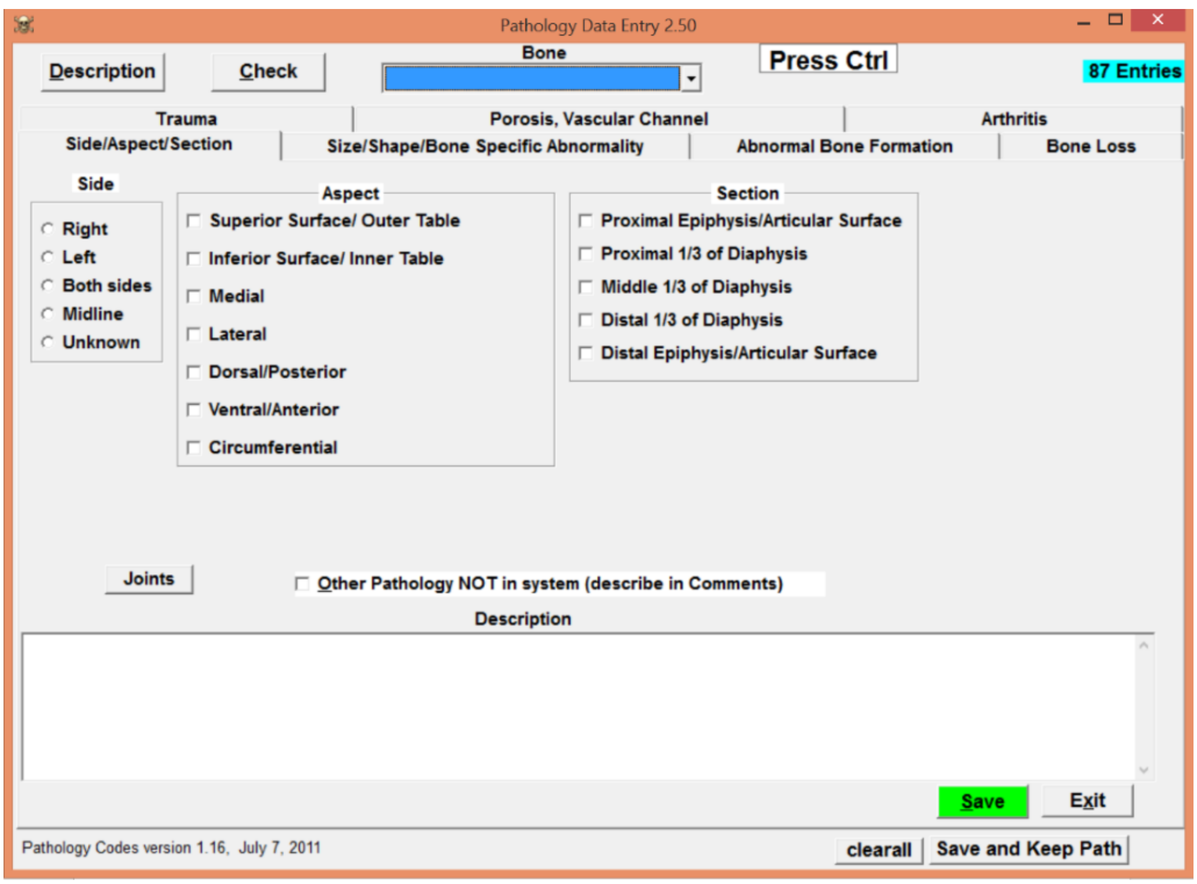

Figure 4. Pathology Module in Osteoware

Trauma Data

Trauma in physical anthropology is traditionally recorded according to a four-tiered classification system: (1) partial or complete break in the bone, (2) abnormal displacement or dislocation of joints, (3) disruption in nerve and/or blood supply affecting healing and/or normal development, and (4) an artificially induced abnormal shape or contour of the bone (Ortner 2003:119-129). The Trauma GUI in Osteoware prompts the user to enter information that classifies the traumatic injury into one of the four aforementioned trauma types. There are two modifications in the Osteoware Trauma GUI that deviate from the *Standards* protocol: (1) an "other" category has been added under the "Fracture Type" heading, and (2) selections for deformation and traumatic enthesopathy have been added under the "Trauma complications" heading (O'Brien and Dudar 2011:44). On the main page of the Trauma GUI, the user is prompted to first classify the fracture type. Under the heading "Fracture Type", the user is prompted by a series of radio buttons, including: Partial (Greenstick/Bowed), Simple (Transverse/Oblique), Comminuted/Butterfly, Spiral, Compression/Torus, Depressed Skull Fracture, Outer Table Involvement Only, Depressed Skull Fracture, Outer and Inner Table Involvement, and Other (Figure 5). Following the Fracture Type classification, the user is prompted to select from a series of fracture characteristics, including: Pathological, Blunt Round, Blunt Oval, Edged/Sharp Force Trauma, Projectile Entry, Projectile Exit, Projectile Embedded, Radiating/Stellate, Amputation, and Other (Figure 5). The Trauma Characteristics menu provides qualitative description of what the user observes. These characteristics may also be used to indicate the type of implement or amount of force involved in the traumatic incident (O'Brien and Dudar 2011:47). Additionally, data is recorded for the timing of the injury (i.e. ante-, peri-, or post-mortem), potential complications, and possible dislocations.

Data exported from the trauma table included all data pertaining to fractures, blunt force trauma, sharp force trauma, projectile trauma, amputations, and dislocations. For the purposes of this research, injuries to the vertebral column, such as spondylolysis and spondylolisthesis, were excluded from the trauma analysis. Cases of myositis ossificans, unless specifically recorded as a 'traumatic' injury (as opposed to a possible accidental or congenital trauma), were also excluded from the trauma analysis.

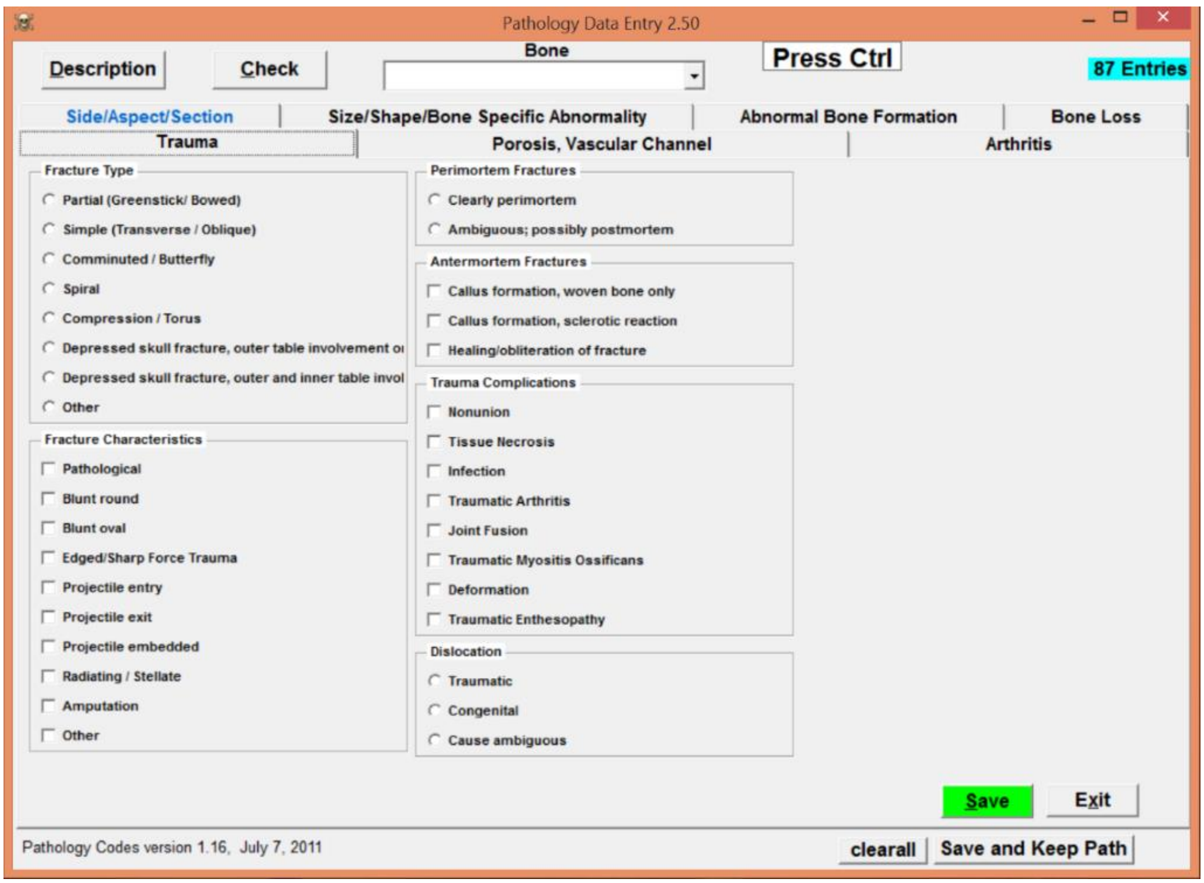

Figure 5. Trauma Graphic User Interface in Osteoware

Supplemental Trauma Documentation

In addition to the qualitative data entered in the Pathology Module, the user can request radiographic and photographic documentation of traumatic injuries. Data recorders in the ROL are encouraged to supplement their skeletal analyses with photographic and radiographic images because some processes affecting internal bone structure may not be visible through visual inspection (Dudar 2011b: 4). While photographic and radiographic images can be requested through the Osteoware GUI, these supplemental materials are not curated with the osteological data in the SI RDBMS.

The majority of photographic documentation of Arikara remains was in the form of 35mm slides, housed in the Museum Support Center. Some photographic documentation was accessible on the ROL shared drive. Some radiographic documentation was also curated on the ROL shared drive, while the remaining hard copies were curated in the ROL and photography studio. All radiographic documentation associated with the Arikara, and that had not previously been digitized, was subsequently scanned by an ROL employee, Janine Hinton, and added to the ROL shared drive.

SKELETAL MATERIALS

For this study, data was exported from Osteoware for 1,221 Arikara individuals (Table 2). All data used in the present study was drawn directly from the SI database. The author did not perform any data collection directly from the bones because requests submitted to the Three Affiliated Tribes to view the skeletal materials went unanswered (requests to work directly with the skeletal materials were submitted via email, telephone, and standard mail). Data was extracted from the following tables: Inventory, AgeSex, CulturalAffiliation, Pathology, and SummPara (Summary Paragraph).

The completeness of each skeleton was based upon the data recorded in the Inventory and Summary Paragraph Modules. Following *Standards*, each skeletal element is assessed independently and recorded as complete (at least 75% of the bone is present), partial (25-75% of the bone is present), fragmentary (less than 25% of the bone is present), or missing. Long bones are recorded as five segments in the Osteoware GUI (proximal epiphysis, proximal 1/3 of the diaphysis, middle 1/3 of the diaphysis, distal 1/3 of the diaphysis, and distal epiphysis). A radio button can be selected for complete elements, otherwise every segment is recorded as complete, partial, fragmentary, or missing (Figure 6). After reviewing the Inventory data, the author assessed the Summary Paragraph which provided a compilation of the observations for each skeleton. The Summary paragraph typically begins with a statement on whether the cranium, mandible, and postcranial skeleton were complete, partial, or fragmentary. Skeletal completeness varied from complete skeletons to incomplete and sometimes fragmentary remains. To account for differential preservation of the skeletal remains, which bias the reported frequencies of trauma by over- or under-enumerating the results, only crania that were at least 50% complete were included in the study. Post-cranial remains were removed from the sample if they were recorded as fragmentary or commingled. Post-cranial remains that were reported in the Summary Paragraph table as “partial,” “nearly complete,” and “complete” were included in the sample. Eliminating partial and commingled remains, the sample was reduced to 990 individuals.

Table 2. Inventory of Arikara Skeletal Remains and Artifacts in the Possession of the National Museum of Natural History (Table 1; Billeck et al. 2005: iii-v)

		Human Remains			Funerary Objects		
Location	**Excavation Year and Excavator**	**Physical Catalog Numbers**	**Arch Catalog Numbers**	**Estimated Number of Individuals**	**Arch Catalog Numbers**	**Number of Objects**	**Site Totals for Human Remains**
Leavenworth (39CO9)	1915/1917 W.H. Over	**2**	**0**	**2**	**0**	**0**	**32**
	1923 M.W. Stirling	27	1	27	97*	2,494*	
	1932 W. D. Strong	2	1	3	16	127	
Nordvold 1 (39CO31)	1923 M. W. Stirling	5	0	6	0*	0*	**52**
Nordvold 2/3 (39CO32/33	1923 M. W. Stirling	39	0	40	0*	0*	
	1932 W.D. Strong	5	0	6	4	149	
Rygh (39CA4)	1932 W.D. Strong 1958/1959 A.L. Bowers 1971 D. Ubelaker & T.D. Stewart	21	0	23	0	0	**23**
Mobridge (39WW1)	1917 W.H. Over	1	0	2	0	0	**375**
	1923 W.M. Stirling	34	1	39	0*	0*	
	1971 D. Ubelaker & T.D. Stewart	312	0	334	63	1,158	
Swan Creek (39WW7)	1920 W.H. Over	13	0	14	0	0	**14**
Cheyenne River (39ST1)	1951/1955/ 1956 W.R. Wedel	76	1	80	144	1,659	**80**
Buffalo Pasture (39ST6/ST216)	1931 W.D. Strong	3	0	3	0	0	**29**
	1955 Unintentional disturbance by mining	35	1	26	5	8	

Table 2 (cont'd)

Indian Creek (39ST15)	1951 Lehmer	2	0	2	7	49	**12**
	disturbance during railroad construction	11	0	10	0	0	
Leavitt (39ST215)	1954/1955 R.P. Wheeler & road disturbance	20	0	22	64	1,605	**22**
Sully (39SL4)	RBS, R.L. Stephenson, & W.M. Bass	560	6	582	378	7,020	**582**
							Total = 1,221 Individuals

* Objects collected by Stirling during the 1923 excavations at Leavenworth, Nordvold, and Mobridge are all listed under the Leavenworth Site due to poor site provenience records.

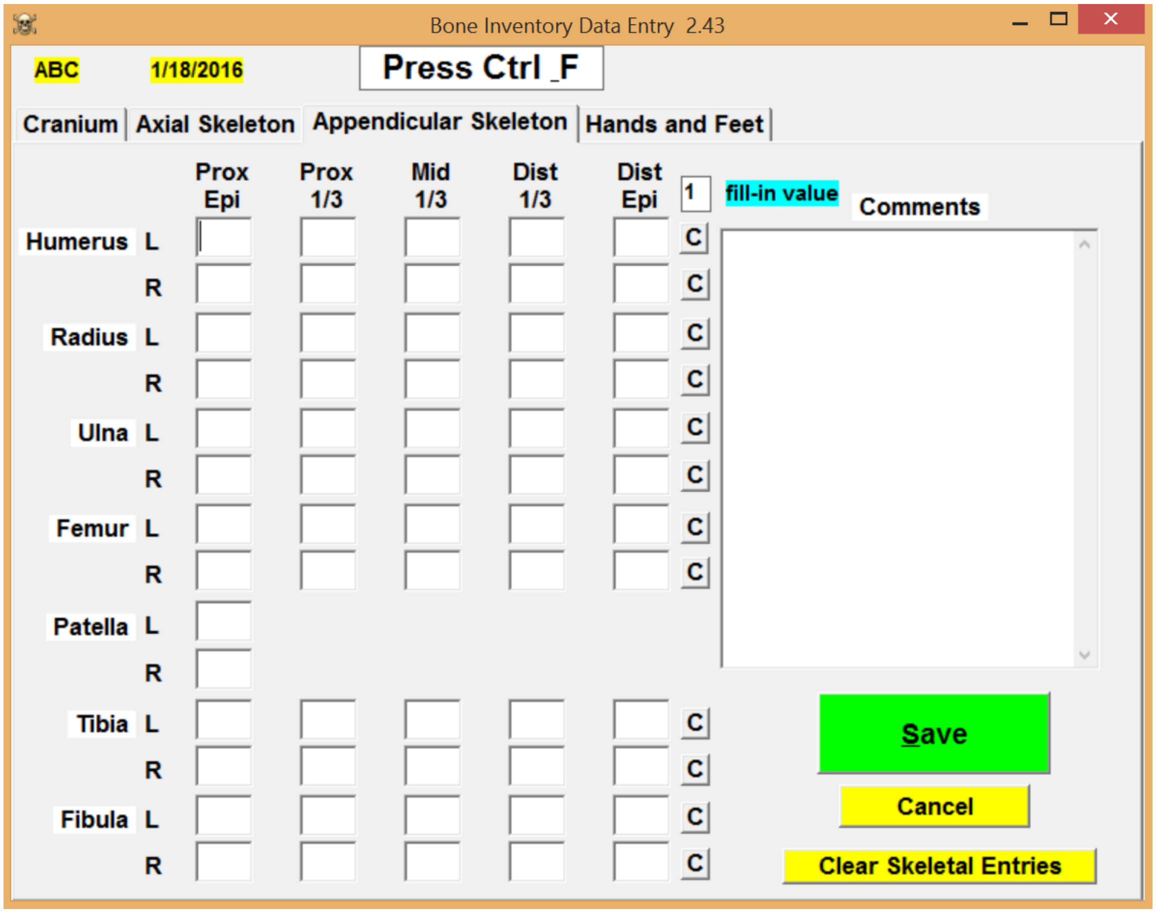

Figure 6. Osteoware Inventory GUI for the Appendicular Skeleton

In the database, 508 individuals were assigned a sex; 266 were males and 242 were females. All individuals assigned a "probable" sex were lumped in with that particular sex category (i.e. "probable males" were included in the "male" category) (Figure 7). In 14 cases, sex could not be determined because of the incompleteness of the remains or the fragmentary nature of the cranium and pelvis. The remaining 468 individuals were those of subadults, ranging in age from intrauterine months to young adolescents, whose sex was not assessed. Sex was estimated by the original data recorder following sex determination methods outlined in *Standards*.

In Osteoware, skeletal ages were reported in two different formats. Some individuals' ages were reported as an age range in a single column (i.e. 17-20), while other ages were reported in two columns in the form of a minimum and maximum. Additionally, individuals could also have both an age range and a minimum and maximum age. The current Age and Sex Module is shown below (Figure 7). Due to the differences in age reporting, each individual was assigned an age-point estimate; age was established as the midpoint of either the age range selected or the average between the minimum and maximum reported ages. Once established, the midpoint was assigned to broad age categories based on *Standards* (Buikstra and Ubelaker 1994:9): Fetal (< birth), Infant (birth-2.5 years), Child (3-11.5 years), Adolescent (12-19.5 years), Young Adult (20-34.5 years), Middle Adult (35-49.5 years), and Old Adult (50+ years).

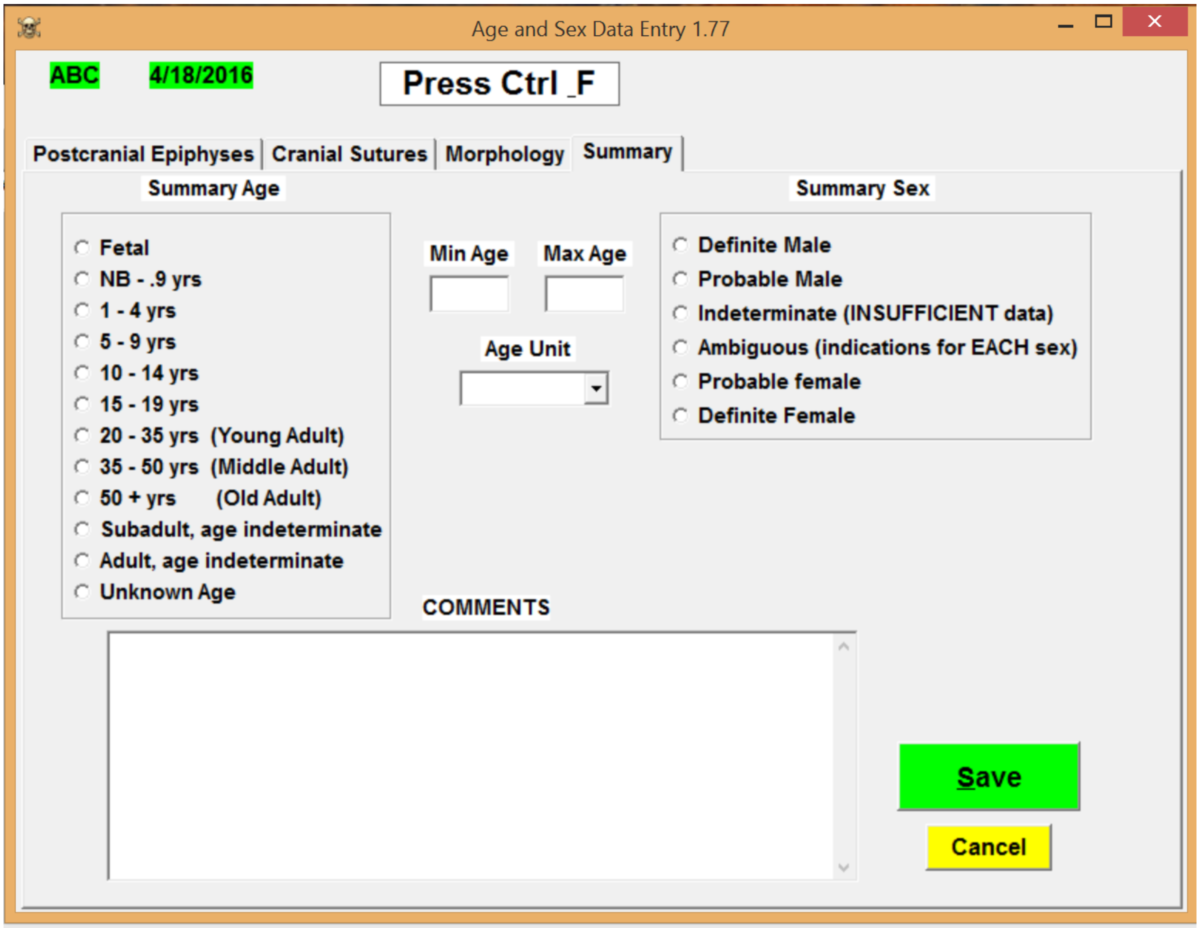

Figure 7. Age and Sex GUI in Osteoware

MORTUARY DATA

SI archaeological data is not associated with the osteological data collected through Osteoware. In the early 1990s the ROL had several databases containing information pertaining to provenience and associated objects, however, these databases were not standardized and were never linked to the osteological database (Dr. William Billeck, personal communication on March 29, 2016). Therefore, mortuary data related to the skeletal sample used in this study were gathered from the Arikara Repatriation Report (Billeck et al. 2005), archaeological site reports, previously published studies using the SI data, and materials housed in the NAA, including RBS materials, archaeological field notes and photographs, SI annual reports, and the Papers of Waldo R. Wedel and Mildred Mott Wedel.

SAMPLE PROVENIENCE

The sample represents the remains recovered from ten archaeological sites in the Middle Missouri River Basin in South Dakota, many of which were obtained under the auspices of the RBS Program (Figure 8). The ten archaeological sites included in this sample were geographically divided into two adjacent regions lying along the Missouri River and defined by Lehmer (1971) as the Bad-Cheyenne Region and the Grand-Moreau Region. Following Lehmer (1971:29), the Middle Missouri, a subarea of the Great Plains, can be further subdivided into smaller units, or regions: Big Bend, Bad-Cheyenne, Grand-Moreau, Cannonball, Knife-Heart and Garrison. The Bad-Cheyenne Region extends north from the mouth of the Bad River to roughly the old Cheyenne Indian Agency, approximately the latitude of Eagle Butte, South Dakota. The Grand-Moreau Region is north and contiguous to the Bad-Cheyenne, extending upstream to 15 miles of the North Dakota-South Dakota border (Lehmer 1971:29). Sites in the Bad-Cheyenne Region include Cheyenne River (39ST1), Buffalo Pasture (39ST6, 39ST216), Leavitt (39ST215), Indian Creek (39ST15), and Sully (39SL4). The Grand-Moreau Region encompasses Leavenworth (39CO9), Anton Rygh (39CA4), Mobridge (39WW1), Swan Creek (39WW7), and Norvold (39CO31, 39CO32, 39CO33). The geographic division of sites allowed for an analysis of violence in two regions of the Middle Missouri River Basin.

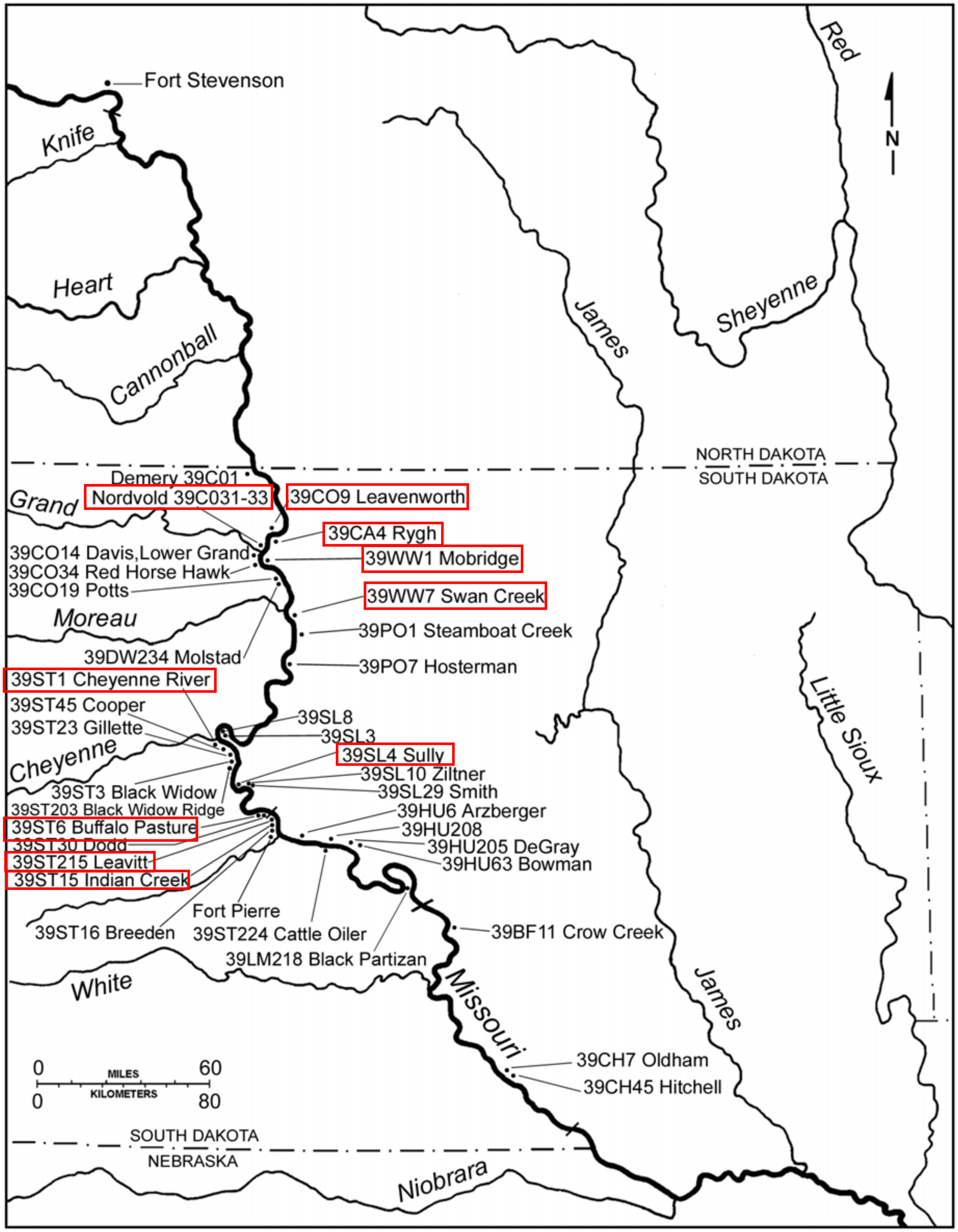

Figure 8. Geographic Distribution of Sites throughout the Missouri River Basin (Figure 2; Billeck et al. 2005: ii)

Chronologically, the sample is composed of individuals dating from the late prehistoric and protohistoric periods to the early historic period. The sites date from the Extended Coalescent (A.D. 1300 – 1650) and Post-Contact Coalescent variants (A.D. 1600 to 1832) (Table 1). Four of the sites (Leavenworth, Buffalo Pasture, Indian Creek, and Leavitt) date to a single variant, the Post-Contact Coalescent (Billeck et al. 2005). The remaining six sites are multi-component sites, with multiple dates of occupation that span two variants, the Extended Coalescent and the Post-Contact Coalescent. Identification of the archaeological variant in the multi-component sites was based on diagnostic grave goods and associated artifacts. These assessments were recorded in the ROL, based on information drawn from archaeological site reports, RBS materials curated in the NAA, previous research, and ROL site descriptions. In some cases, burials were assigned on a case-by-case basis with burials containing European trade goods (i.e. glass, metal, etc.) assigned to the Post-Contact Coalescent variant and those that did not contain European derived goods assigned to the Extended Coalescent variant. This method was used in cases where multi-component sites, with multiple occupation periods, could not be reliably separated by component (i.e. each occupation represented by separate component or cemetery). The chronological classification system was also based on information drawn from field notes and the Arikara Repatriation Report.

Table 3. Site Information for Arikara Sample Including Site Name, Time Period, Geographic Region and Number of Individuals

Site Name	Time Period	Geographic Region	Number of Individuals
Leavenworth (39CO9)	Post-Contact Coalescent	Grand-Moreau	30
Mobridge (39WW1)	Extended Coalescent, Post-Contact Coalescent	Grand-Moreau	308
Norvold (39CO31, 39CO32, 39CO33)	Extended Coalescent, Post-Contact Coalescent	Grand-Moreau	49
Swan Creek (39WW7)	Extended Coalescent, Post-Contact Coalescent	Grand-Moreau	12
Cheyenne River (39ST1)	Extended Coalescent, Post-Contact Coalescent	Bad-Cheyenne	78
Buffalo Pasture (39ST6, 39ST216)	Post-Contact Coalescent	Bad-Cheyenne	26
Indian Creek (39ST15)	Post-Contact Coalescent	Bad-Cheyenne	9
Leavitt Cemetery (39ST215)	Post-Contact Coalescent	Bad-Cheyenne	22
Sully (39SL4)	Extended Coalescent, Post-Contact Coalescent	Bad-Cheyenne	440
Anton Rygh (38CA4)	Extended Coalescent, Post-Contact Coalescent	Grand-Moreau	16

Osteological data were exported from the SI RDBMS, Osteoware, using SQL. The requirements for inclusion into the sample were as follows: (1) all sites were determined by the ROL to be affiliated with the Arikara tribe; (2) all individuals were independently determined by the ROL to be affiliated with the Arikara tribe following a geographic, temporal and skeletal analysis of craniometrics; and (3) each site had at least 9 individuals. In addition to the individuals included in the sample, each site also had associated commingled remains. Commingled were excluded from the sample, primarily due to the often fragmentary and incomplete nature of the remains.

SITE DESCRIPTIONS

Leavenworth (39CO9)

Leavenworth, also known as the Lewis and Clark Village, consists of historic period villages and cemeteries known to have been occupied by the Arikara between roughly 1803 and 1832 (Billeck et al. 2005; Wedel 1955:80-81). Leavenworth is the earliest site that can be definitively linked to an Arikara occupation using historic records (Billeck et al. 2005). Situated on a terrace off the west bank of the Missouri River in Corson County, South Dakota, the archaeological site represents the remains of what used to be two fortified villages of approximately 70 lodges each separated by Elk or Cottonwood Creek (Billeck 2007; Billeck et al. 2005). In addition to the two fortified villages, the Leavenworth Site is associated with five cemetery areas located on a higher terrace above the village (Billeck 2007).

In May of 1823 Arikara warriors from the Leavenworth Site attacked a fur trading expedition led by William H. Ashley resulting in the death of several trading party members (Billeck et. al. 2005; Billeck 2007). In retaliation, the U.S. Army, in alliance with the Sioux, attacked the village, shelling the lodges and their inhabitants in August of the same year. During this attack, the Arikara villagers fled the village in the night and the village remained vacant for a year before the Arikara returned (Billeck 2007:229). This period of reoccupation was not long-lasting, however, and Leavenworth was again found unoccupied when Karl Bodmer and Prince Maximilian passed the site in 1832 (Morgan 1964:329; Thwaites 1906:355-6).

The first recorded excavations of the site were conducted by William H. Over in 1915 and 1917, when Over was acting as the director of the University of South Dakota museum (Billeck 2007:229). William H. Over excavated both the village and associated cemeteries. The next series of excavations were conducted in 1923 by Matthew W. Stirling on behalf of the

Smithsonian Institution (Billeck 2007). The site, including four houses and several refuse heaps, and three graves, were excavated by William Duncan Strong in 1932. Before the site was flooded, due to the damming of the Missouri River, the site was again excavated by the University of Nebraska in the years 1960 and 1962 (Billeck 2007:229). A final series of cemetery excavations were supervised by William Bass with the University of Kansas during the summers of 1965 and 1966 before the villages and some associated cemeteries were inundated by Lake Oahe (Billeck 2007).

Human skeletal remains curated at the SI's National Museum of Natural History (NMNH) include 2 individuals recovered by Over during his 1915 and 1917 field seasons, 27 individuals excavated by Stirling in 1923, and 2 individuals excavated by Strong in 1932. In addition to the skeletal remains analyzed by the SI, the NMNH accessioned a number of associated artifacts. One hundred and twenty-seven funerary objects were accessioned at the NMNH in association with William Duncan Strong's 1923 excavation of the Leavenworth Site (Billeck et al. 2005). Unfortunately, because artifact provenience was often not recorded during Stirling's 1923 excavations of Leavenworth, Nordvold 1, Nordvold 2/3 and Mobridge, many objects cannot be identified to specific sites and burial contexts (Billeck et al. 2005). The Leavenworth Site dates to the Post-Contact Coalescent variant.

Nordvold 1 (39CO31), Nordvold 2 (39CO32), and Nordvold 3 (39CO33)

There are three sites on the west side of the Missouri River in Corson County, South Dakota, that share the Nordvold site designation; Nordvold 1 (39CO31), Nordvold 2 (39CO32), and Nordvold 3 (39CO33; Billeck et al. 2005:120). It is possible that all three villages shared cemeteries so the three sites are considered together for the purposes of this research. All three sites represent fortified villages; two cemeteries in close proximity to the villages were also excavated (Billeck et al. 2005:120). One cemetery is thought to have been associated with Nordvold 1 and is named “Norvold 1”. A second cemetery, Norvold 2/3, is located between and to the north of Nordvold 2 and Nordvold 3, roughly a quarter mile south of the Norvold 1 cemetery (Billeck et al. 2005:120).

The first recorded excavation at the Nordvold sites took place in the summer of 1923 and was led by Matthew J. Stirling, then assistant curator of the Division of Ethnology at the NMNH (Billeck et al. 2005:120). In 1923, Stirling excavated four cemeteries, naming them Cemeteries 1, 2, 3, and 4, respectively. In 1955, Waldo Wedel examined the field notes and materials recovered from each of the four cemeteries and determined that Stirling’s Cemetery 1 was associated with the Mobridge Site, Cemetery 2 with the Leavenworth Site, Cemetery 3 with Norvold 1, and Cemetery 4 with Nordvold 2/3 (Billeck et al. 2005:120). In total, the NMNH curates 46 individuals recovered by Stirling in 1923, six individuals from Nordvold 1 and 40 individuals from Nordvold 2/3 (Billeck et al. 2005:120). An additional five individuals from Nordvold are present at the NMNH, these individuals excavated by W.D. Strong in 1932 from the cemetery associated with Nordvold 2/3. RBS staff visited the site in 1951, however, the site was not recommended for further study as the location was not to be affected by construction of the Oahe Dam.

Nordvold 1 is a single component village dating to the LeBeau Phase of the Post-Contact Coalescent (Johnson 1994:370; Billeck et al. 2005:121). Nordvold 2/3, however, had multiple occupations and it is probable that the cemetery contains burials from both occupations of the site (Billeck et al. 2005:121). Key (1983:31), using cranial measurements, assigned the cemetery to the Extended Coalescent. The presence of historic trade goods in a number of the burials, however, suggests that this interpretation is incorrect and that the cemetery is either entirely from the Post-Contact Coalescent occupation of the site or is a mix of Extended Coalescent and Post-Contact Coalescent burials (Billeck et al. 2005:121). Because of the discrepancies associated with dating the site, Norvold 2/3 was associated with the Extended Coalescent, but all individuals with historic grave goods were assigned to the Post-Contact Coalescent.

Anton Rygh (39CA4)

The Anton Rygh Site, referred to here as Rygh, represents an earthlodge village on the east bank of the Missouri River in Campbell County, South Dakota (Billeck et al. 2005). The village is thought to have covered approximately four acres and contained at least 58 houses (Billeck et al. 2005). Rygh is surrounded by a fortification ditch and associated bastions, suggesting the possibility of attack. In 1932, the first excavation of the site was conducted by William Duncan Strong. The remains of an infant were recovered with associated artifacts. Alfred L. Bowers led a series of excavations under the auspices of the RBS in the years 1957, 1958, 1959 and 1963 (RBS 1928-1969: Site File 39CA4). William M. Bass excavated the Rygh cemetery in 1969 and four individuals were excavated from an eroding embankment in the year 1971 by Douglas Ubelaker and T.D. Stewart, working for the SI. The Rygh Site is a multi-component site with human remains from the Extended Coalescent and the LeBeau phase of the Post-Contact Coalescent (Billeck et al. 2005). The NMNH analyzed and curated data on 23 individuals from the Rygh site: one individual from Strong's 1932 excavation, 16 individuals from Bower's 1958 excavation, two individuals from Bower's 1959 excavation, and four individuals collected during Ubelaker and Stewart's excavation in 1971. Based on a lack of trade goods associated with burials, most burials were assigned to the Extended Coalescent. However, one individual buried with historic grave goods was assigned to the Post-Contact Coalescent.

Mobridge (39WW1)

The Mobridge Site consists of an earthlodge village located on the east bank of the Missouri River in Walworth County, South Dakota (Billeck et al. 2005:160). There is controversy whether the site was fortified. Burials have been excavated from three cemeteries associated with the site; each with a designated Feature number, 1, 2 and 3 respectively (Billeck et al. 2005:160). William M. Bass describes the features in an unpublished report on the site, and Douglas W. Owsley (1981:43) summarizes this description as follows: "Feature 1 is a small hill west of the village. Feature 2 is a large, long hill two to three hundred yards south of the village. Feature 3 is a small knoll about one hundred yards south of Feature 1. A fourth area not excavated, but destroyed by construction activity is located on a slight knoll east of the village."

The first recorded excavations of the site were led by W.H. Over in 1917. He excavated a number of large refuse mounds (Billeck et al. 2005:160). Over returned four years later and recovered 65 skulls and eight skeletons from a cemetery in the year 1920. Based on Over's descriptions of the site, it appears that he excavated in Feature 1 in 1917 and in Feature 2 in 1920 (Billeck et al. 2005:160). Two individuals from Over's 1917 excavation are present at the NMNH. In 1923, Matthew W. Stirling conducted a series of excavations at Mobridge while he was employed as assistant curator in the Division of Ethnology, NMNH. Stirling excavated four cemeteries, designated Cemetery 1, 2, 3, and 4, and in several villages (Stirling 1924:66). In the 1950s, Waldo R. Wedel consulted with Matthew Stirling to determine the location of Cemeteries 1-4 and determined that Cemetery 1 was associated with the Mobridge site. Thirty-nine individuals from Stirling's Cemetery 1 are present at the NMNH. Mobridge was recorded by the RBS in July of 1946, but was not excavated because the site was not going to be affected by the Oahe Reservoir. RBS staff visited the site again in 1951, 1952 and 1953, when they collected several artifacts from the surface (Billeck et al. 2005:162). In the summers of 1968, 1969, and 1970, William M. Bass excavated in each of the three features and recovered a total of 371 burials; none of those remains are at the NMNH. Finally, in 1971, T. Dale Stewart and Douglas H. Ubelaker excavated a portion of Feature 2, recovering 334 individuals, all of which were curated at the NMNH (Billeck et al. 2005:162).

Mobridge is a multi-component site with an Extended Coalescent occupation and a Post-Contact Coalescent occupation (Billeck et al. 2005). Remains recovered during Over's 1917 excavations are attributed to Feature 1. It is not known for sure what feature Stirling's Cemetery 1 belongs to. Stirling believed that Cemetery 1 was located "about 300 yards north of the village," leading Wedel to hypothesize that Cemetery 1 was a separate burial feature not noted in previous excavations (Wedel 1955:86). Using craniometrics, Owsley (1981) demonstrated that the individuals excavated from Stirling's Cemetery 1 are most similar to other crania excavated from Features 1 and 3, which have been associated with the Extended Coalescent. Billeck, on the other hand, opposes this theory and states that Cemetery 1 is in fact a part of Feature 2, a feature associated with a Post-Contact Coalescent occupation of the site. For the purposes of this research, Stirling's Cemetery 1 is assigned to Feature 2.

Multiple occupations of the site are evidenced by a different distribution of European manufactured trade goods found with burials (McKeown 2000). McKeown states that "few trade goods were recovered from Features 1 and 3 while 20% of the burials excavated from Feature 2 during the 1970 field season contained objects indicative of European contact" (2000:59; Owsley et al. 1981:180). This led McKeown to assign Features 1 and 3 to the Extended Coalescent and Feature 2 to the Post-Contact Coalescent (2000:59). Craniometric data analyzed by Owsley et al. (1981) lend credence to this temporal separation between the features at the Mobridge site. For this research Features 1 and 3 were therefore assigned to the Extended Coalescent, while Feature 2 was assigned to the Post-Contact Coalescent.

Swan Creek (39WW7)

The Swan Creek site lies on the east bank of the Missouri River near the mouth of Swan Creek in Walworth County, South Dakota. The site encompasses an area of land roughly 1230 by 1170 feet including several earthlodge depressions, refuse mounds, a fortification ditch and a cemetery located on a rise east of the village (Billeck et al. 2005; Hurt 1975:2-3). Swan Creek was first recorded by William H. Over in 1920, when he began excavations (Billeck et al. 2005). Over returned and directed subsequent excavations of the site in 1928 and 1932 (Billeck et al. 2005:251). More than 20 years later, the site was excavated by Wesley R. Hurt in 1954 and 1955, in conjunction with the RBS. Sixty-two individuals were recovered during this two-year period and none of the human remains were sent to the NMNH. A total of 36 individuals were recovered by Over in 1920, however, only 14 of these individuals were assessed by the ROL. The vast majority of individuals in the NMNH collections from Swan Creek Site are represented only by a crania and and/or associated mandible. Only two individuals have postcranial elements (one case has only a pelvis present).

The Swan Creek Site may represent four separate occupations, one dating to the Extended Coalescent and three to the Post-Contact Coalescent (Hurt 1975). One individual recovered from the site is thought to be of European origin providing further evidence of a Post-Contact occupation to which the site was assigned (Billeck et al. 2005). The NMNH does not house funerary objects from the Swan Creek site.

Cheyenne River (39ST1)

The Cheyenne River Site lies on a high terrace on the west bank of the Missouri River roughly 1000 feet from the mouth of the Cheyenne River in Stanley County, South Dakota (Billeck et al. 2005). A partial manuscript written by Waldo Wedel (ca. 1930-1980: Box 84) divided the site into three areas. Area 1 was situated on the river embankment and consisted of 20 northward-facing earthlodge depressions enclosed by a fortification ditch (Billeck et al. 2005). In the early 1900s, Area 1 began to slump into the Missouri River, and before RBS could begin excavation of the site, erosion had destroyed a northeastern portion of the area, consuming 11 of the earthlodge depressions (Wedel ca. 1930-1980: Box 84, partial draft manuscript; Billeck et al. 2005:264). Just south of the Area 1 fortification ditch lie five earthlodge depressions and several smaller depressions for caches or other pits, comprising Area 2. Area 3, directly east of Areas 1 and 2, consisted of 28 earthlodge depressions, a number of smaller depressions for caches or pits, and a cemetery. Neither Area 2 or 3 was fortified, but both contained round and rectangular earthlodge depressions consistent with a Coalescent Tradition habitation and a Middle Missouri Tradition occupation (Billeck et al. 2005:264).

The Cheyenne River Site has been excavated on multiple occasions. W.H. Over visited the site in 1917, noting that roughly one-third of the fortified village in Area 1 had eroded into the river (Billeck et al. 2005:264). Over returned to the site in 1921 and excavated eight graves in Area 3 (Sigstad and Sigstad 1973:247-251: Billeck et al. 2005:264). In 1931, Alfred Bowers excavated portions of all three Areas including the fortification ditch and earthlodges in Area 1, a grave and caches in Area 3, and a single grave in Area 2 (Bowers 1940:153-157; Billeck et al. 2005:264). Eight years later William Duncan Strong visited the site and performed a surface collection, but did not excavate (Billeck et al. 2005:264). RBS recorded the site in 1948 with

Paul L. Cooper leading an archaeological survey and minimal excavation of areas to be affected by construction of the Oahe Dam (Billeck et al. 2005:264). Three years later in 1951, Waldo Wedel led a field crew for RBS and excavated two circular earthlodges, a portion of the fortification ditch in Area 1, and three rectangular earthlodges and three cache pits in Area 3 (Cooper 1955:68; Billeck et al. 2005:264). Surface collections were conducted in 1952 and 1953 (Billeck et al. 2005). In 1955, Wedel returned and with the help of George Metcalf excavated a portion of a rectangular earthlodge that had previously been partially excavated in 1951 (Smithsonian Institution 1958:54). Wedel returned in 1956 and excavated 55 graves in the Area 3 cemetery and also a circular and rectangular earthlodge also in Area 3 (Smithsonian Institution 1958:54).

There are two major cultural components and a minor one at the Cheyenne River Site (Billeck et al. 2005:265). The earliest component is represented by the rectangular earthlodge depressions in Areas 2 and 3. This component has been assigned to the Extended Middle Missouri (Johnson 1994; Lehmer 1971; Thiessen 1977) and dates to approximately A.D. 1200-1300 (Johnson 1994:370). The second component dates approximately A.D. 1500-1550 and belongs to the Extended Coalescent (Johnson 1994:370; Lehmer 1971: figure 77). The third component is represented by the cemetery in Area 3 and the fortified village in Area 1, both assigned to the Bad River Phase of the Post-Contact Coalescent, dating to approximately A.D. 1700-1750 (Johnson 1994; Lehmer 1971; Lehmer and Jones 1968). A total of 80 individuals from the Cheyenne River site are house at the NMNH; two individuals originated from Area 1, one individual from a Middle Missouri tradition house depression, one individual excavated from the bluff, and 76 individuals excavated from the cemetery in Area 3. All of the remains, except from the individual excavated from the Middle Missouri house depression, are likely associated with the Bad River phase of the Post-Contact Coalescent occupation of the site (Billeck et al. 2005:279).

Buffalo Pasture (39ST6/39ST216)

The Buffalo Pasture Site includes a village (39ST6) and cemetery (39ST216) located on a flat terrace on the west bank of the Missouri River (Billeck et al. 2005). The site covers an area roughly 525 by 375 feet, and is thought to have contained 30 earthlodges based on surface depressions. The village is surrounded by a fortification and the cemetery is located roughly 100 feet southeast of the fortification and across a ravine (Billeck et al. 2005:295). The site was first visited by William Duncan Strong, who referred to the site as the Old Fort Village, in 1931 (Billeck et al. 2005:295). During this visit, Strong excavated human remains that had become partially exposed in the bank of a ravine (Strong, 1931; 1928-1969: Box 19, 1931-1932 Nebraska-South Dakota expedition field notebook). W.H. Over excavated middens just outside of the village fortification, recovering buffalo bones and pottery (Billeck et al. 2005: Sigstad and Sigstad 1973:247). The date of this excavation is unknown. In 1939, Albert C. Spaulding, a graduate of Strong at Columbia University, conducted the first formal excavations at the site (Lehmer and Jones 1968:5). Seven years later, in 1946, Waldo R. Wedel surveyed the site on behalf of the RBS and recommended it for future study (Billeck et al. 2005:295). RBS excavations were led by Franklin Fenenga in 1952 and by Carl F. Miller and Richard P. Wheeler in 1955 (Billeck et al. 2005:295). Also in 1955, the Lytle and Green Construction Company, while mining for fill dirt for the Oahe Dam, disrupted a number of burials in the Buffalo Pasture cemetery. Subsequent attempts to locate the disturbed burials *in situ* were unsuccessful (Billeck et al. 2005). Human skeletal remains and associated artifacts curated by the NMNH come from the 1955 excavations by the RBS and from the 1931 excavations conducted by Strong (Billeck et al. 2005). Although Strong only reported the recovery of a single individual in 1931, there are three individuals he is thought to have recovered and subsequently transferred to the NMNH. Twenty-six individuals were recovered by the RBS in 1955 (Billeck et al. 2005:301). The cemetery and village date to the Bad River Phase of the Post-Contact Coalescent.

Indian Creek (39ST15)

The Indian Creek site represents a village and cemetery located on the west side of the Missouri River and on the north bank of Indian Creek in Stanley County, South Dakota (Billeck et al. 2005:307). The site was first visited in 1948 by Waldo R. Wedel, Frederick Johnson, Gordon Baldwin, and Paul Cooper working on behalf of the RBS during an inspection before the Oahe Dam construction. The cemetery was accidently discovered in 1951 by the Army Corp of Engineers during the construction of an access railroad for the dam (Billeck et al. 2005). Donald J. Lehmer excavated two grave pits in the cemetery that same year, and in 1952, Franklin Fenenga performed exploratory excavations of the village (Billeck et al. 2005). The Indian Creek Site is thought to have two distinct components: a cemetery dated to the Bad River Phase of the Post-Contact Coalescent and associated with the Arikara tribe, and an Extended Middle Missouri component most likely associated with the Mandan (Billeck et al. 2005). There are 12 individuals from the Indian Creek site that were analyzed by the NMNH: two individuals from the grave pits excavated by Lehmer in 1951 and 10 individuals from the disturbance of the cemetery by the Army Corp of Engineers that same year. The presence of European trade goods in the two grave pits suggests that the cemetery dates to the Post-Contact Coalescent.

Leavitt (3ST215)

The Leavitt Site represents the remains of a village and a cemetery. The site is multicomponent and the village has been dated to the Extended Coalescent variant, while the cemetery is Post-Contact Coalescent and likely not associated with the Leavitt village. It is probable that the cemetery was used by the inhabitants of the nearby Phillips Ranch village (Billeck et al. 2005). The Leavitt archaeological site covers roughly 500 by 400 feet and is located on a flattened terrace on the west bank of the Missouri River in Stanley County, South Dakota (Billeck et al. 2005). The site was discovered in 1954 when burials were unintentionally disturbed by the construction of a road. Richard P. Wheeler, on behalf of the RBS, collected the remains disturbed during road construction. Wheeler returned the following year and excavated portions of both the village and cemetery (Billeck et al. 2005). In total, the NMNH possesses 22 individuals from the Leavitt site: 16 individuals excavated from the cemetery and six individuals uncovered by construction. All individuals from Leavitt come from the Post-Contact Coalescent.

Sully (39SL4)

The Sully Site represents a large unfortified, earthlodge village located on the east bank of the Missouri River in Sully County, South Dakota. The location of the village is near a former military post called Fort Sully and the site has formerly been referred to as the Fort Sully earthlodge village (Billeck et al. 2005:357). The site covers roughly 1,000 by 4,400 feet and contains over 200 house depressions, more than any other known Arikara village (Billeck et al. 2005:357). On the north side of the village are five cemeteries, designated A through E. As outlined in the SI Repatriation Report "Cemetery A was located about 1,000 feet north of the center of the village. To the south of Cemetery A and about 650 feet from the edge of the village was Cemetery B. Cemetery E was west of Cemetery A and about 650 feet from the edge of the village. Cemetery D was west of Cemeteries A and E and located along the edge of the village. Cemetery C was located approximately 500 feet east of the village" (Billeck et al. 2005:357). Cemetery C appears to represent an earlier area of scaffold burial area that is not associated with the Sully earthlodge village and therefore will not be considered here (Billeck et al. 2005). The village and all five cemeteries were inundated following the construction of the Oahe Dam.

The Sully Site was first excavated by Alfred W. Bowers in 1930 and 1931. Bowers excavated in one of the cemetery areas and in the village, uncovering 49 burials (Billeck et al. 2005:357). The RBS visited the site in 1948, 1949, and 1950, when they collected surface material and recommended the site for further study. Two individuals collected from the surface in 1948 are present at the NMNH. The RBS returned in 1953 and conducted test excavations of the site. In 1956, Robert L. Stephenson directed a RBS crew and human remains were recovered from the village. Stephenson continued excavation in the village in 1957 and 1958. William W. Bass directed cemetery excavations in 1957, 1958, 1961 and 1962 (Billeck et al. 2005:359). A minimum of 582 individuals from Sully are located at the NMNH (Billeck et al. 2005:462).

The Sully Site appears to have had multiple occupations with inhabitants at different periods utilizing different cemeteries (cemeteries designated A through E by Bass). Based on the presence of European trade goods in all of the cemeteries, the Sully Site was initially thought to represent Post-Contact Coalescent villages. Jantz (1997) and Key (1983), however, attribute Cemeteries A and D to the La Roche Phase of the Extended Coalescent variant and Cemeteries B and E to the Le Beau Phase of the Post-Contact Coalescent. In contrast, Billeck et al. (2005:462) suggest that the cemeteries at Sully were probably in continual use and each cemetery contains burials from both the Extended Coalescent and Post-Contact Coalescent. For Sully, the sample was first assigned a date based on Cemeteries A and D assigned to the Extended Coalescent, and

Cemeteries B and E assigned to the Post-Contact Coalescent. Next, because each of the cemeteries contained graves with historic trade objects, placing the burials in the Post-Contact Coalescent variant, individuals were separated on a case-by-case basis based on objects placed in the grave. For example, if an individual was excavated from a cemetery assigned to the Extended Coalescent, but the burial contained historic trade goods, the individual was assigned to the Post-Contact Coalescent.

SIOUX COMPARATIVE SAMPLE

A second sample of Native American data was exported from the SI database for comparison with the Arikara. The comparative sample is affiliated with the Sioux tribe, specifically the Oglala and the Brule Sioux. The Sioux sample derives from archaeological sites in South Dakota and Nebraska and consists of 77 individuals: 37 males, 25 females, 14 subadults and one individual of an indeterminate sex. Only 19 of the 77 Sioux remains included post-cranial elements, therefore this portion of the research focused only on cranial elements.

SUMMARY

All osteological data used in the present research comes from the SI and was previously collected on behalf of the ROL between the years 1993 and 2012. The skeletal sample from which data was collected consists of 990 individuals associated with the Arikara tribe and an additional 77 Sioux. All Sioux data was used in a comparative fashion against the Arikara sample to identify differences in the pattern and frequency of skeletal injuries observed between the tribes. Additionally, information was drawn from archaeological site reports, RBS materials curated in the NAA, previous research using the SI collections, the Arikara Repatriation Report, and associated photographic and radiographic documentation.

CHAPTER 7: METHODS

In order to conduct an analysis of interpersonal violence using the Arikara osteological data, it was first necessary to learn the SI relational database, Osteoware, and the relational database management system, Advantage™. Extraction of data from the SI RDBMS involved writing SQL statements, after which data had to be cleaned and normalized prior to statistical analysis. This section will outline each of these steps in turn.

THE OSTEOWARE PROGRAM

Before analyzing data at the SI, osteological data was collected from a small sample of skeletal materials housed at Michigan State University. All data was entered into Osteoware so the author could familiarize herself with the Osteoware system and GUIs. Osteological data was collected and entered into the Osteoware modules, with emphasis placed on the Pathology Module. For an in-depth discussion of data entry and the Osteoware Pathology Module, the reader is directed to the Osteoware software Manual Volume II: Pathology (Wilczak and Jones 2011). The recording system for the Pathology Module is based on guidelines outlined in *Standards.* A key for the coding system utilized in the Pathology Module can be found in Appendix A. For an example of data entry using Osteoware and the SI coding system (Pathology Module; Side/Aspect/Section and Trauma GUIs), see Table 4:

Table 4. Example of Qualitative Data Entry in the Osteoware Pathology Module

Bone	Humerus
Side	Right
Aspect	Middle 1/3 of Diaphysis
Fracture Type	Other
Fracture Characteristics	Projectile Embedded
Antemortem Fractures	Callus formation, sclerotic reaction
Trauma Complications	Infection

For the above qualitative observations, the RDBMS would store the record in a coded form as show below (Table 5):

Table 5. Example of Coded Qualitative Data Exported from Advantage™

Type	Bone	Side	Aspect	Sect	obs1	obs2	obs3	obs4	obs5	obs6	obs7
5	411	1	34	3			29	36		62	73

The author did not work directly with the live version of the SI database, but imported legacy data tables directly into Advantage™ on a personal computer.

EXPORTING OSTEOLOGICAL DATA

Advantage™, working in conjunction with Osteoware, allows the user to manage, query and extract data from the SI relational database. The primary function of Advantage™ is to make aggregate data accessible. Data was extracted from the SI RDB using SQL. The Advantage™ RDBMS allows the user to export data in a variety of formats (e.g. Excel, HTML, and CSV). A comprehensive presentation of SQL is beyond the scope of this dissertation. Because the purpose of this research is to demonstrate the accessibility of the data in the SI RDBMS, this section concentrates on a few basic SQL queries as well as simple JOIN statements.

Basic SQL Queries

SQL is a computer language designed to interact with databases, and its main function is to provide a simple and efficient way to both manage and query (search) a database (Forta 2013). The primary focus of this research was querying a relational database and not database management or data manipulation. SQL uses English terms in the form of statements which can be considered the command or request of the user. The terms used in SQL statements are known as keywords and the most basic query is a SELECT statement. Using a SELECT statement to retrieve data from a database, the analyst must write at least two lines of SQL code, defining the data wanted, and the table selected. In this sense, SQL is a somewhat intuitive form of code writing. For example, if the user wants to select the variables minimum age (MinAge), maximum age (MaxAge), and catalog number (Catkey) from the AgeSex table, he/she would write the following code:

SELECT MinAge, MaxAge, Catkey
FROM AgeSex

As this example shows, the user must know the column headers and table names to employ SQL for data mining. Therefore, the user must first explore the RDB and learn the relationships between the tables and the variables included in each table prior to extracting data from the database. The variables in a table can be learned either by writing a simple "Select All" statement (SELECT *; FROM Table A) which will return all columns in Table A or through visual inspection of the database. In the Advantage™ RDBMS, all table names are listed on the left-hand side of the screen (circled in blue; Figure 9). A complete list of the SI RDMS table names and variables can be found in Appendix B.

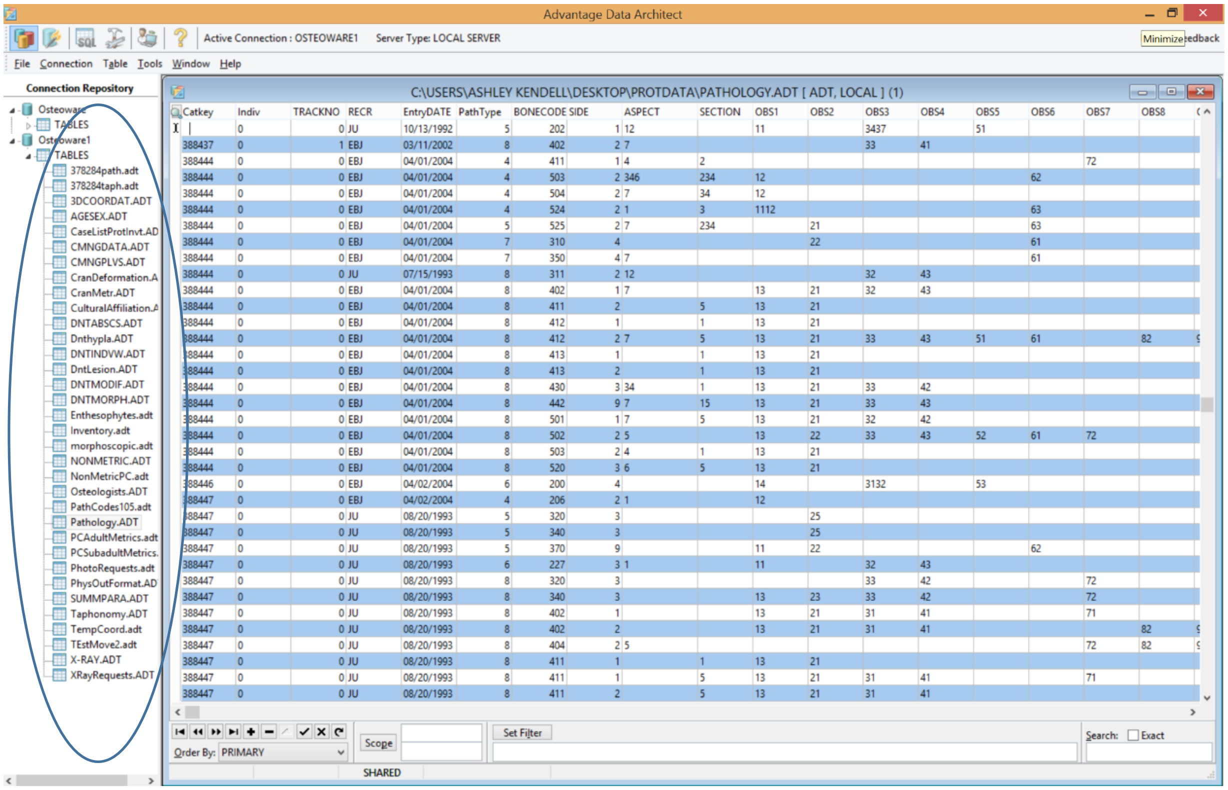

Figure 9. Advantage Data Architect™

Another basic SQL query requesting data from a single table can be composed using a SELECT, FROM, and WHERE statement. In each statement, the user specifies the data wanted with the SELECT command, the table of interest with the FROM command, and the conditions under which data will be extracted using the WHERE command (shown below).

SELECT column_name_1, column_name_2, ……..etc.
FROM table name
WHERE filter condition [Where clause Operators include = (Equality), < (Less than), > (greater than), etc.]

Again, this query allows the user to export data from a single table in the RDB. The first basic query used in this research project was a query to extract all Catkeys associated with individuals recovered from each of the ten sites in the study.

Table Join SQL Statements

One of SQL's most powerful features is the capability to join multiple tables in a single data retrieval query. Tables are joined on the primary key. In Osteoware, the primary key is usually the Catkey (catalog number). However, in cases of commingled individuals, the primary key is a combination of several fields, including Catkey, Indiv (Individual number or RBS number), and sometimes the Trackno (Tracking Number). The primary key can be used to build relationships between tables within the database. These relationships are referred to as table joins, and multiple variables can be combined from several tables into a single output screen. In the SQL statement below, tables are joined on the primary key with the statement "WHERE a. Catkey = b.Catkey." Each table is assigned a letter and the same letter is used as a prefix for each column in the desired table (see below; Dudar 2011a). A simple join statement is shown below.

SELECT A.column_name_1, A.column_name_2,…..B.column_name_x (A. and B. are table name aliases established in the FROM statement)
FROM table name A, table name B
WHERE A.primary key = B.primary key (the join condition which joins tables A and B on their primary keys)
AND filter condition(s)

Unlike the basic SQL statements above, the above query has two tables in the FROM clause. The two tables are joined with the WHERE clause that instructs the RDBMS to match the primary key in Table A with the primary key in Table B. Each column has a qualifier that indicates which table it is drawn from (i.e., "A.columnname_1 is drawn from table A"). Otherwise the RDBMS cannot tell where the column originates. This clarification is especially critical when there is ambiguity regarding the columns' location in the database. The query below was used in the present research and combined data on biological profile, skeletal pathology and the osteology summary paragraph for all individuals associated with the Leavenworth Site. Four tables were joined in this query: AgeSex, Cultural Affiliation, Pathology and the Summary table. Data was only exported for individuals with Catkeys associated with the Leavenworth Site.

```
SELECT a.Catkey, a.MinAge, a.MaxAge, ca.Sex, ca.SiteName, p.BONECODE, s.SummPara
FROM AgeSex AS a
JOIN CulturalAffiliation AS ca
ON a.Catkey = ca.Catkey
JOIN Pathology AS p
ON a.Catkey = p.Catkey
JOIN SUMMPARA AS s
ON a.Catkey = s.Catkey
AND a.Catkey in
('315533','315534','325339','325340','325341','325410','325342','325412','325421','325343','3253
44','325345','325346','325419','325347','325348','325349','325401','325403','325350','A325515','3
25351','325407','325407A','325352','325405','325353','325406','325354','385951','385952','A517
349')
```

Below is a schematic of the tables used in the above query with each table joined on its primary key (Figure 10).

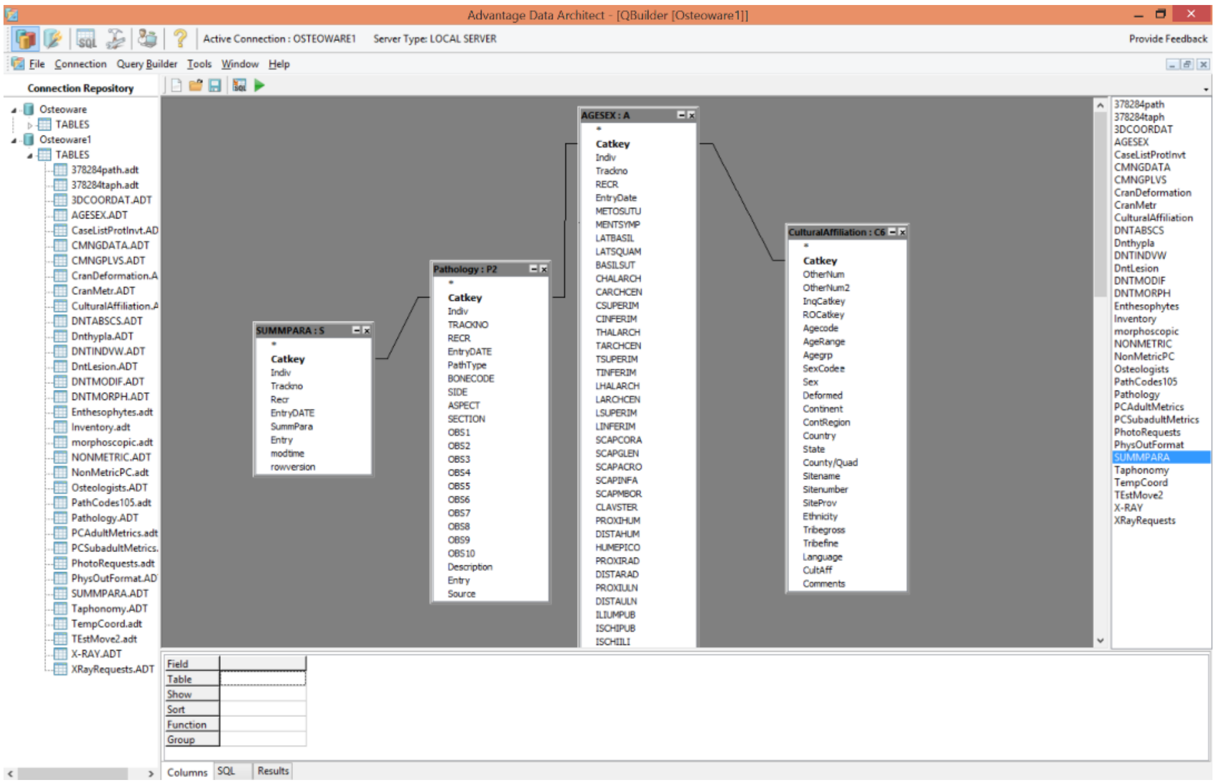

Figure 10. SUMMPARA, Pathology, AGESEX, and CulturalAffiliation Tables Joined Using their Primary Keys

Wildcards are special characters used to match a value or a part of a value, the most common wildcard being the percent sign (%; Forta 2013). By adding a wildcard (%) to a WHERE clause, the user searches for keywords in the designated column. A wildcard search must be employed with the LIKE operator which instructs the RDBMS to search for a wildcard match, rather than a straight equality match (Forta 2013:54). Wildcard searches can only be used in text fields and the % tells the RBDMS to retrieve any characters that contain the designated word, regardless of the number of characters. For example, %trauma% retrieves the words “trauma”, “traumatic”, “non-traumatic”, etc.

After desired data had been extracted from the tables outlined in the materials section, the author employed a wildcard search to query for traumatic injuries that had not been recorded in the Trauma Module. Wildcard searches were run for the words trauma, myositis ossificans, and fracture. When the wildcard search found a condition identified as "traumatic" in nature, this pathology was added to the trauma data used in the study. As an example, one case of myositis ossificans was recorded in the Abnormal Bone Formation Table, however, in the description the recorder noted that the injury was likely the result of a traumatic injury. Consequently, the lesion was included in the trauma sample. In the example below, the query returns the requested columns for all individuals that have the keyword “trauma” in the trauma description field.

SELECT Catkey, Indiv, Description
FROM Pathology
WHERE Description LIKE '%trauma%'

Finally, all pathology data was integrated with the corresponding photographic and radiographic images. When an injury was documented in the radiographic or photographic record and was not qualitatively recorded in the relational database, the author described the osteological lesion and created a new record for the pathology. This only happened on two occasions.

DATA CLEANING AND NORMALIZATION

After the data were exported from the RDBMS, it was necessary to clean and normalize the results. The following modifications were made to the osteological dataset; otherwise all data was kept in its original form for statistical analysis. Each individual in the sample was categorized as having cranial remains only, post-cranial remains only, or both cranial and post-cranial remains present. This categorization was necessary to establish trauma frequencies in the sample. In Osteoware, trauma data is recorded by element. Once exported, these data were re-categorized by body region. The skeleton was divided into five regions: facial (splanchnocranium with the addition of the frontal), cranial vault (parietals, occipital, temporals, sphenoid), axial skeleton (vertebrae, ribs, and sacrum), upper appendage (bones of the shoulder, arm and hand), and lower appendage (innominates and bones of the leg and foot). Additionally, injuries were identified by trauma type: (1) fracture of a long bone, (2) dislocation, (3) blunt force trauma, (4) sharp force trauma, and (5) projectile trauma.

INTER-OBSERVER ERROR

A traditional assessment of inter-observer error was not conducted in this study because the author was unable to obtain permission from the Three Affiliated Tribes to examine the skeletal materials. All individuals included in the study had previously been offered to the Three Affiliated Tribes following repatriation protocols. According to SI policy, skeletal materials that have been offered for repatriation are only accessible following explicit approval by tribal representatives. All data used in the study therefore had been previously collected by ROL employees. During the data collection phase, some depressed cranial fractures recorded in Osteoware were not visible in the associated photographic and radiographic images. In an effort to assess inter-observer error, the present study compared the frequency of depressed cranial fractures recorded in Osteoware with the frequency of fractures both documented and visible in the supplementary documentation. Chi-square tests were calculated in SPSS 23.0 (SPSS Inc., Chicago IL), with significance set at α =.05.

GENERAL TRAUMA ANALYSIS

For the general trauma analysis, skeletal injuries of both an accidental and intentional nature were assessed. An exploratory data analysis was conducted to assess the frequency of trauma at each site included in the sample. Trauma frequencies were also calculated when the Arikara sample was assessed in its entirety.

Chi-square and Fisher's exact tests were calculated for all prevalence comparisons between the sexes, different regions, and contact periods. A chi-square test for association assesses whether two categorical variables are associated, or more specifically, whether two variables are statistically independent (Drennan 2009:183). Phi (φ) assessed the strength of association for nominal-by-nominal relationships.

Multinomial logistic regression (MLR) is a multivariate classification method that generalizes logistic regression for variables with more than two discrete outcomes. MLR, as a model, predicts the probability of different possible outcomes for categorically distributed dependent variables from a set of independent variables. MLR was calculated to assess the pattern of injuries between the sexes, by age groups and between different temporal periods. Statistical analyses were run in SPSS 23.0 (SPSS Inc., Chicago IL), with significance set at α =.05.

Due to the nature of the data and to the small number of variables assessed, all statistical analyses were calculated in SPSS. A number of tests were run in R (e.g. correspondance analysis), however, the low number of variables and the lack of demographic information made plotting features in R less desirable than the simple graphical representations available in SPSS.

ANALYSIS OF INTERPERSONAL VIOLENCE

Trauma is broadly defined in the field of bioarchaeology and traumatic injuries include those defects of both an accidental and intentional nature. For this reason, the statistical analysis of trauma was subdivided into injuries potentially resulting from interpersonal violence. Past bioarchaeological research pertaining to interpersonal violence has focused on identifying markers of interpersonal violence on the human skeleton. Evidence of interpersonal violence, historically, has focused on craniofacial trauma and injuries derived from projectile points or other forms of weaponry (e.g. Andrushko and Torres 2011; Buzon and Richman 2007; Dawson et al. 2003; Fiorato et al. 2000; Jurmain et al. 2009; Kanz and Grossschmidt 2006; Lambert 1994; Lessa and Medonca de Souza 2004, 2006; Murphy et al. 2010; Owens 2007; Paine et al. 2007; Smith 1996, 1997, 2003; Standen and Arriaza 2000; Steadman 2008; Torres-Rouff and Costa Junqueira 2006; Tung 2007; Walker 1989, 1997; Webb 1995; Willey and Emerson 1993). Several studies have included perimortem mutilation (i.e., trophy-taking of body parts and scalping) as an additional indicator of interpersonal violence (Andrushko et al. 2005; Andrushko et al. 2010; Bartelink et al. 2014; Steadman 2008; Tung 2007, 2008; Tung and Knudson 2008; Verano 2003). For the purposes of this study, markers of interpersonal violence include cranial trauma (both craniofacial and cranial vault), projectile injuries, and evidence of perimortem mutilation (specifically scalping and the taking of trophy skulls).

Interpersonal Violence Statistical Methods

As with the statistical analysis of trauma, chi-square tests were calculated for all prevalence comparisons between the sexes, age categories, regions and time periods, and Fischer's exact tests were applied when counts were less than five. Again, statistical analyses were calculated in SPSS 23.0 (SPSS Inc., Chicago IL), with significance set at α =.05.

COMPARATIVE SIOUX SAMPLE

To further delineate social interactions through time and in different regions of the Missouri River Basin during the Post-Coalescent variant, the study assessed the frequency of skeletal markers indicative of interpersonal violence within a sample of Sioux skeletal remains curated at the NMNH. The comparative sample was composed of Oglala and Brule Sioux and derived from archaeological sites in South Dakota and Nebraska. Sioux data was exported from the SI RDB using SQL. Because the vast majority of Sioux skeletal remains did not have associated post-cranial elements, only crania were assessed. The Sioux sample consisted of 77 crania dating to the Post-Contact period. Chi-square and Fischer’s exact tests were calculated for all prevalence comparisons between the sexes and age groups. Because only crania were assessed, skeletal markers of interpersonal violence included craniofacial and cranial vault trauma. Statistical analyses were calculated in SPSS 23.0 (SPSS Inc., Chicago IL), with significance set at α =.05. The results of the Sioux interpersonal violence analysis were compared with the results of Arikara analysis.

CHAPTER 8: RESULTS

With the enactment of repatriation legislation, recognition of the loss of knowledge and access to Native materials became a driving force for the collection of massive amounts of osteological data. This research was the first of its kind to evaluate the documentation, curation, and accessibility of SI osteological data collected from Native American remains. With this research, the main objective was to evaluate the accessibility of the SI relational database to address bioarchaeological research questions of repatriated collections. After evaluating the SI relational database structure and accessibility, the research analyzed trauma in the SI's Arikara collection. While the Arikara materials represented one subset of the Native American collections (roughly 7% of the skeletal collection), it is hypothesized that the methods will be applicable to any other SI materials or the collection as a whole. Further, the research focused on trauma because of personal interests in skeletal trauma analysis and the bioarchaeological interpretation of interpersonal relationships in past populations.

This section will outline the issues encountered while working with the SI RDB and RDBMS, present a brief discussion of inter-observer error when working with digitized osteological data, summarize the results of the Arikara trauma analysis and the results of the comparative analysis between the Arikara and the Sioux.

DATA ACCESSIBILITY

Overall, accessing osteological data from the SI database was a success. SQL proved to be an efficient and highly effective tool for isolating the data necessary for an analysis of trauma. While a basic understanding of SQL code was necessary, the extraction of data was accomplished using basic or simple join statements. However, there were a number of complicating factors that made data extraction and manipulation more complex than anticipated. These issues will be identified and elaborated.

The first complication in osteological data accessibility was encountered when working with the data recorded from the Sully Site. As mentioned in the methods section, all individual records have a primary key, in most cases the primary key for the Arikara data was the Catkey (museum catalog number). After isolating the Catkeys for individuals excavated from the Sully Site, it was noted that the query retrieved only half of the individuals reported in the Arikara repatriation report. Inspection of the database showed that many individuals with the Catkey beginning with "388..." were recorded under the Catkey "39SL4," which is the site number for Sully. The primary key for these cases was instead the Indiv column (individual number or RBS number). These individuals had to be extracted from the database using a different query method that searched for a separate primary key than the rest of the Sully sample. Without access to the Arikara Repatriation Report and a working knowledge of the Arikara sample, nearly half of the individuals from the Sully Site would have been inaccessible due to the lack of standardization of data reporting for the site.

A second complication of working with the data curated by the SI is the inability to generate a percent complete for skeletal elements. Following *Standards*, all long bones are recorded as five segments in the Osteoware GUI (proximal epiphysis, proximal 1/3 of the diaphysis, middle 1/3 of the diaphysis, distal 1/3 of the diaphysis, and distal epiphysis). A radio button can be selected for complete elements, otherwise every segment is recorded as complete (1; at least 75% of the bone is present), partial (2; 25-75% of the bone is present), or fragmentary (3; less than 25% of the bone is present). This data recording process results in five columns of data with codes ranging from 1 to 3, but no direct reporting of the percentage complete for the bone as a single element. The cranial data is recorded in a similar format with each cranial bone indicated as complete, partial, or fragmentary. Without examining a photograph or developing an algorithm based on the mid-point of the percent complete for each separate bone, there is no way to evaluate whether a cranium is at least 50% complete (criteria for inclusion in the study). This issue was resolved by referencing the summary paragraph in the inventory table and associated photographs (when available), however, using only qualitative data, establishing element completeness is complicated and fairly inaccurate.

As noted in the materials section, radiographic and photographic documentation of the Arikara remains are also not curated within the SI database. Some of the supporting documents are curated externally in a separate shared drive utilized by ROL employees. However, not all radiographic images have been digitized and most are housed as hard copies in the ROL photography studio. Access to all materials was straightforward and forthcoming, however, the structure of the database did not support the integration of digitized images that corresponded to the osteological qualitative data.

The complications outlined above, of working with and extracting data from the SI osteological database, are minor and did not undermine the project goals. However, there was one complicating factor that significantly hindered a bioarchaeological analysis of the Arikara skeletal materials. Data pertaining to archaeological materials and artifact provenience is not currently integrated with the osteological data at the SI. Initially, the research hoped to include a bioarchaeological mortuary analysis of the remains. However, this was not possible because a searchable archaeological database does not exist. Therefore, information regarding burial goods and burial provenience were drawn from the repatriation report and original site reports. In some cases, provenience was unknown due to the accidental nature of recovery of the human remains and artifacts. Some of the burials and cemeteries were disturbed during dam construction under water resource development projects in the 1950s. Due to the incomplete nature of the archaeological data, a mortuary analysis was not included in the present study.

In summary, working with Osteoware and Advantage™ was successful and the Arikara osteological data was easily isolated and exported using the RDBMS. However, while the osteological data was easily accessible, the osteological data is not linked to the mortuary data thereby hindering bioarchaeological analysis of the human remains. While original research can be conducted using the SI osteological data, the osteological data cannot be contextualized using associated mortuary, archaeological, or burial provenience data. This lack of integration of the archaeological and provenience data limited interpretations of the skeletal record and inhibited the application of a bioarchaeological approach to assessing interpersonal violence in the Arikara tribe.

INTER-OBSERVER ERROR

In an effort to assess inter-observer error, all documentation from the SI RDBMS related to depressed cranial fractures was compared with the associated photographic and radiographic materials. Because the author did not have permission to work directly with the skeletal materials, comparing the data with these supplemental materials was the only way to assess inter-observer error. The osteological data included 65 reported cranial injuries. Of these 65 injuries, 38 were documented as depressed cranial fractures. In comparing the osteological data with the associated photographs and radiographs (when available), it was determined that the cranial injuries were visible in only 27 (71%) of the 38 cases. It is probable that the majority of injuries were present. However, many injuries were not visible due to the angle of the photograph, a failure to demarcate the injury from the surrounding bone, the absence of photographic or radiographic documentation, or erroneous recording. When comparing the frequency of depressed cranial fractures based on the qualitative data recorded in Osteoware versus injuries visible in the photographic or radiographic record, there was not a statistically significant difference in trauma frequency (X^2=1.96; *df*=1; p=0.1617).

While there was not a statistically significant difference between the trauma frequencies computed using the Osteoware data compared to the photographic and radiographic materials (p=0.1617), it is noteworthy that depressed cranial fractures were only visible for 71% of the individuals with reported fractures. As an example, an Old Adult male, age 70+, from the Sully Site was recorded in Osteoware as having three shallow, well-healed depression fractures. Two depression fractures were noted on the frontal and a small depression was said to be present on the left parietal. None of the depressed cranial fractures were visible in the photographic or radiographic documentation and therefore could not be corroborated by the author (Figure 11). This finding reflects the potential for over-estimating trauma frequencies when using archival data. This is not to say that the depressed cranial fractures were recorded in error, however, using digitized osteological data does not always allow for visual inspection of skeletal remains or a secondary assessment of the previously recorded data.

Figure 11. Photographic and Radiographic Documentation of an Old Adult Male, Age 70+, from the Sully Site with Depressed Cranial Fractures Recorded in Osteoware

SKELETAL TRAUMA

General Trauma Analysis

Of the 990 individuals in the sample, 125 (12.6%) exhibited skeletal trauma. The frequency of trauma varied when the sites were evaluated separately and ranged from 7.7% (Buffalo Pasture) to 55.6% (Indian Creek) (Table 6).

Table 6. Trauma Frequencies per Site

	Trauma = No	Trauma = Yes
Indian Creek (n=9)	4 (44.4%)	5 (55.6%)
Leavenworth (n=30)	23 (76.7%)	7 (23.3%)
Rygh (n=16)	13 (81.3%)	3 (18.7%)
Nordvold (n=49)	40 (81.6%)	9 (18.4%)
Swan Creek (n=12)	10 (83.3%)	2 (16.7%)
Leavitt (n=22)	19 (86.4%)	3 (13.6%)
Cheyenne River (n=78)	68 (87.2%)	10 (12.8%)
Sully (n=440)	384 (87.3%)	56 (12.7%)
Mobridge (n=308)	280 (90.9%)	28 (9.1%)
Buffalo Pasture (n=26)	24 (92.3%)	2 (7.7%)

When sites are assessed individually, it is worth noting that the frequency of trauma is higher in males than females in seven of the ten sites included in the sample (Figure 12). Also, there are few instances of trauma in subadults with the exception of the Leavenworth Site where the subadult trauma frequency is 21.4% (3/14). The trauma frequency of adults at the Leavenworth Site is also high, with 37.5% of females displaying injuries and 11.1% of males. Leavenworth is the only historic site and has the second highest trauma frequency of any site in the sample.

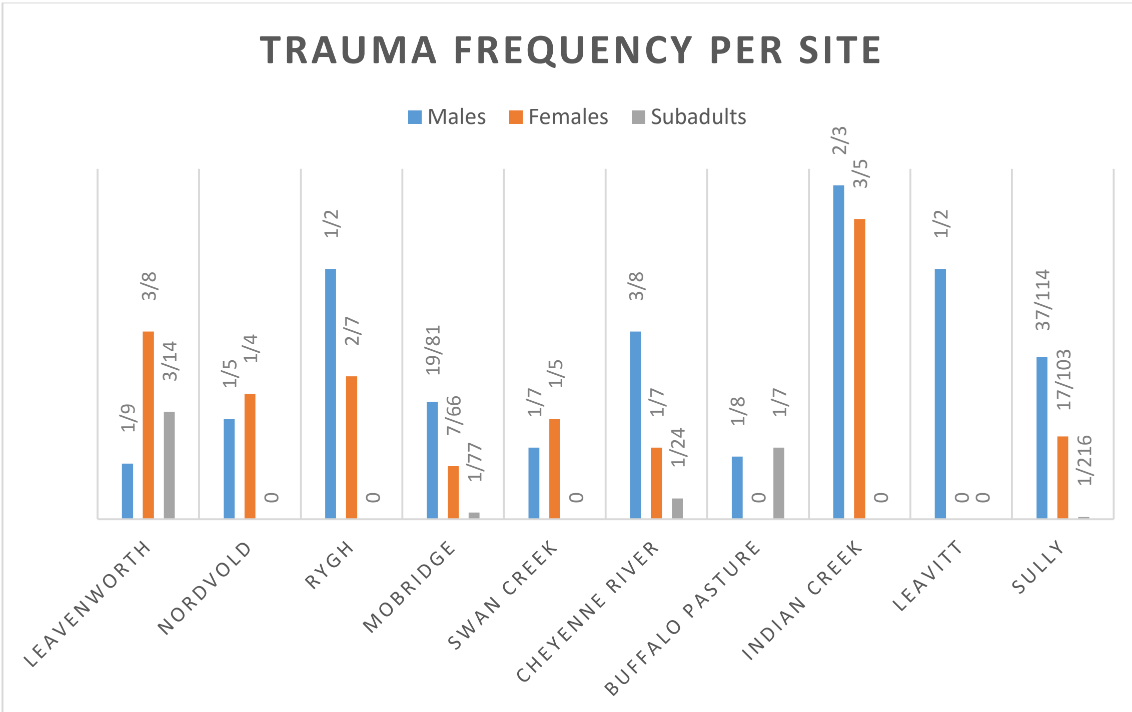

Figure 12. Trauma Frequencies per Site with Counts for Sex and Age

Many of the human skeletal remains analyzed by the SI were collected through the RBS. The RBS Program, conducting salvage archaeology, did not always collect skeletal remains in a systematic manner and not every site included in the study yielded an accurate sample of the site's population. For sites such as Indian Creek, where the sample size is nine and the trauma frequency is 55.6%, it is probable that the trauma frequency is not an accurate representation of that particular place and time. Because of this, trauma frequencies are likely best represented when presented as aggregate data combining the sites together and then dividing the sample both temporally and regionally. For the remainder of the trauma analysis, trauma frequencies will be reported for SI Arikara sample in aggregate.

Sex Differences

In the database, 508 individuals were assigned a sex; 266 were males and 242 were females. This count omitted subadults (n=468) and individuals of indeterminate sex (n=14). A chi-square test for association was conducted between sex and trauma. All expected cell frequencies were greater than five. There was a statistically significant association between sex and trauma (X^2= 9.848; *df*=1; p=0.002) and the strength of the association was moderate (φ=0.139; *p* =0.002). Males had significantly higher levels of skeletal trauma with 28.2% of males exhibiting trauma (75/266) and only 16.5% of females manifesting trauma (40/242) (Figure 13).

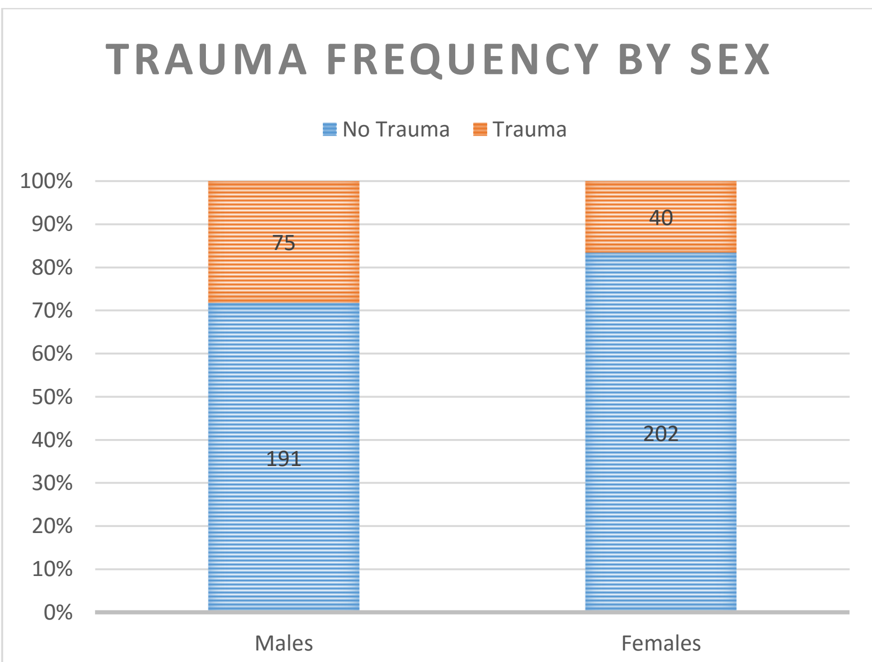

Figure 13. Trauma Frequencies Compared Between the Sexes

When traumatic injuries were assessed by the region of the body where they occurred, differences between the sexes were also observed. The most commonly affected region in both sexes was the splanchnocranium with the addition of the frontal (Region 1). The second most common areas injured in females were injuries to the cranial vault, followed by the upper appendage, the axial skeleton, and finally the lower appendage (Figure 14). After facial trauma, males were most likely to exhibit trauma to the lower appendages, followed by upper appendages, axial skeleton and finally the cranial vault (Figure 14). A chi-square test for association was conducted between sexes and body regions affected by trauma. All expected cell frequencies were greater than five. There was a statistically significant association between sex and body region, (χ^2=13.966; df=4; p=0.007), and this association was found to be strong (φ=0.309; p=0.007). Females had a higher frequency of cranial vault trauma than expected, while males had a higher frequency of trauma to the lower appendage than was expected.

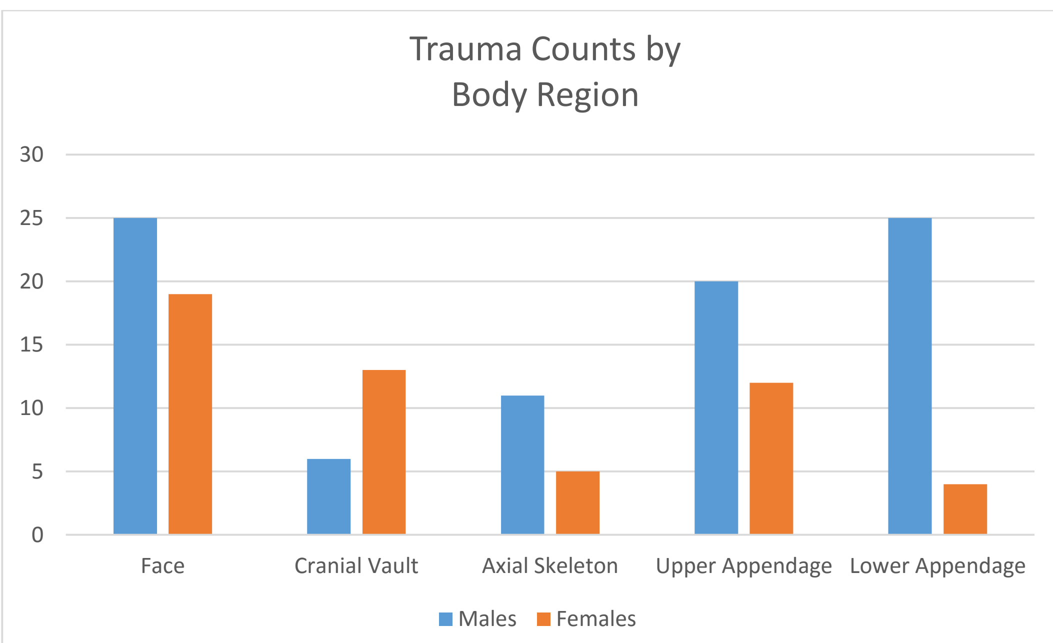

Figure 14. Patterns of Trauma by Body Region Between the Sexes

When trauma was assessed by time of the injury, only 12 individuals had injuries sustained during the perimortem interval. All other trauma showed evidence of healing and was therefore recorded as occurring in the antemortem interval. Of the 12 individuals with perimortem trauma, six individuals were male, three female, two adolescents, and one child (5-7 years). When comparing perimortem injuries between the sexes, all three females with perimortem injuries exhibited depressed cranial fractures. Both Adolescents (one individual was recorded as female, aged 15-18 years) exhibited evidence of scalping (cut marks on the cranial vault) (Figure 15, A). The data indicated that while only one female (Adolescent) sustained weapon-related trauma, five of the six males with perimortem trauma exhibited skeletal manifestations of weapon-related violence. Perimortem injuries in males included a musket ball injury to the ilium, blunt force cranial trauma with evidence of potential trophy taking (drill holes), sharp force trauma to the cranium, and two cases of sharp force trauma to the axial skeleton (Figure 15, B, C and D). The final male with perimortem trauma had vertebral compression fractures in thoracic vertebrae 11 and 12.

A.

B.

C.

Figure 15. Perimortem Injuries

Figure 15 (cont'd)

D.

A. Cut marks indicative of scalping on the occipital. Adolescent female, age 15-18 years. Rygh Site.

B. Entrance wound from musket ball. Young Adult male, age 24-27 years. Leavitt Site.

C. Right third rib with sharp force trauma on the ventral 1/3 of the rib body. Middle Adult male, age 30-40 year. Cheyenne River Site.

D. A perimortem depressed cranial fracture, possibly made with an edged weapon to the left aspect of the frontal bone. Middle Adult male, age 40-45 years. Mobridge Site.

There are 20 cases of injury recidivism in the sample, with individuals having more than one skeletal injury. Of these 20 cases, ten recidivists were females and ten males. The two individuals with the highest frequency of skeletal trauma are both male. One is a Middle Adult male (30-49 years) with four injuries: (1) perimortem blows to the left and right parietals, with subsequent modification for potential use as a trophy skull, (2) antemortem depressed fracture to the right eye orbital; (3) healed depressed cranial fracture to the left parietal, and (4) perimortem fracture to the left mandibular ramus. The injuries occurred at different times, indicating that this individual was involved in violent interactions on at least two separate occasions. The individual with the highest frequency of trauma is an Old Adult male, age 70+ with six injuries: (1) the cranium has three shallow, well-healed depression fractures, (2) the sacrum has a healed fracture on the right side of the first neural arch which resulted in deformation of the neural spine, (3) the right acetabulum has a severe dislocation-fracture that resulted in disuse of the joint and formation of a pseudo-acetabulum directly superior to its original location, likely the result of the trauma to the sacrum, (4) the left ulna has a complete fracture of its proximal joint, (5) the right patella has several fracture lines on both its dorsal and ventral surfaces, and (6) the distal joint of the left tibia has a small antemortem fracture on the dorsal margin and joint surface. All injuries occurred antemortem and therefore it is impossible to say whether the injuries are the result of more than one violent interaction.

Age Differences (Fetal to Old Adult)

In the sample, age categories were assigned as follows: 12 Fetal remains, 280 Infants, 139 Children, 123 Adolescents, 183 Young Adults, 174 Middle Adults, and 79 Old Adults. The frequency of trauma per age category is presented below (Table 7):

Table 7. Trauma Frequency by Age Category

Age Category	Frequency of Trauma
Fetal	0/12 (0%)
Infant	0/280 (0%)
Child	6/139 (4.3%)
Adolescent	14/123 (11.4%)
Young Adult	28/183 (15.3%)
Middle Adult	44/174 (25.3%)
Old Adult	33/79 (41.8%)

A statistically significant difference emerged when comparing age groups and trauma frequency (χ^2= 58.942; *df*=4; *p*=0.000). Both Middle Adults and Old Adults had levels of trauma much higher than expected for the sample.

There was also a statistically significant association between adult age and body region affected by trauma, (χ^2= 23.131; *df*=8; *p*=0.003). The strength of association between sex and body region was very strong (φ=0.416; *p*=0.003). Middle Adults had a higher frequency of trauma to the axial skeleton than expected, while Old Adults had a higher frequency of trauma to the upper appendage than was expected. The increased incidence of trauma to the axial skeleton in Middle Adults appeared to reflect an increased frequency in males alone, because females have a very low level of axial trauma in middle age (Figures 16 and 17). When analyzing the pattern of trauma between the sexes, it is also worth noting that Young Adult females have a higher frequency of facial trauma (when compared to other regions of the body) than is observed in the older age categories (Figure 16). A different pattern emerges in males where Middle Adults exhibit a proportionally higher frequency of injuries to the lower appendage than is seen in younger or older males (Figure 17). Both sexes exhibit a heightened frequency of trauma to the upper appendage as age increases.

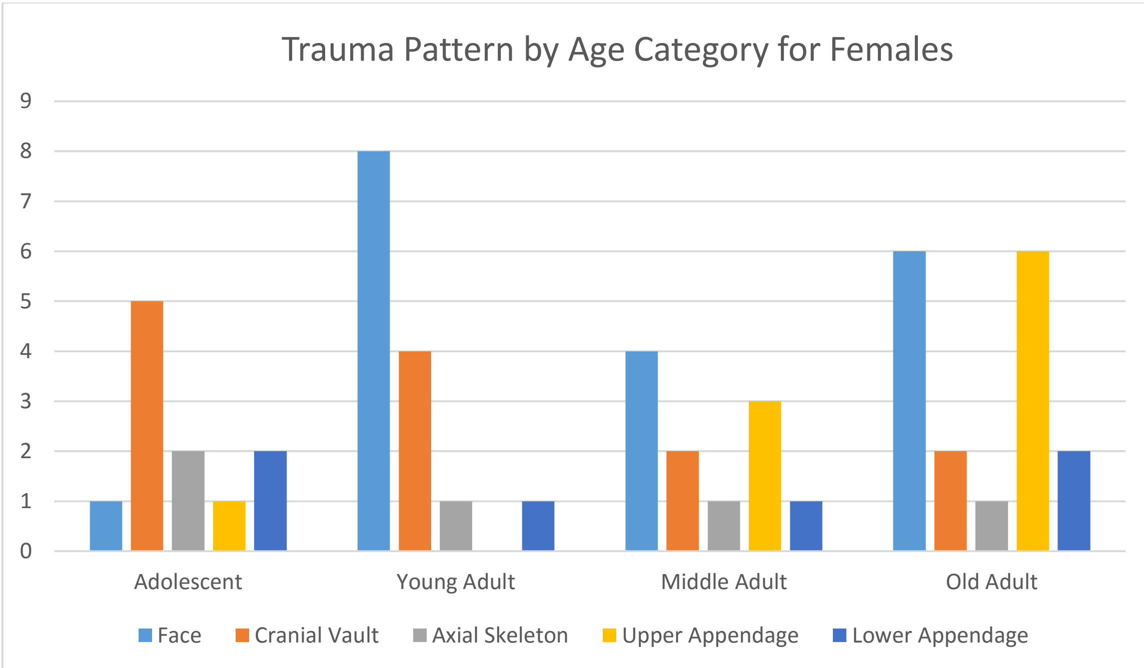

Figure 16. Injury Patterns by Age Category for Arikara Females

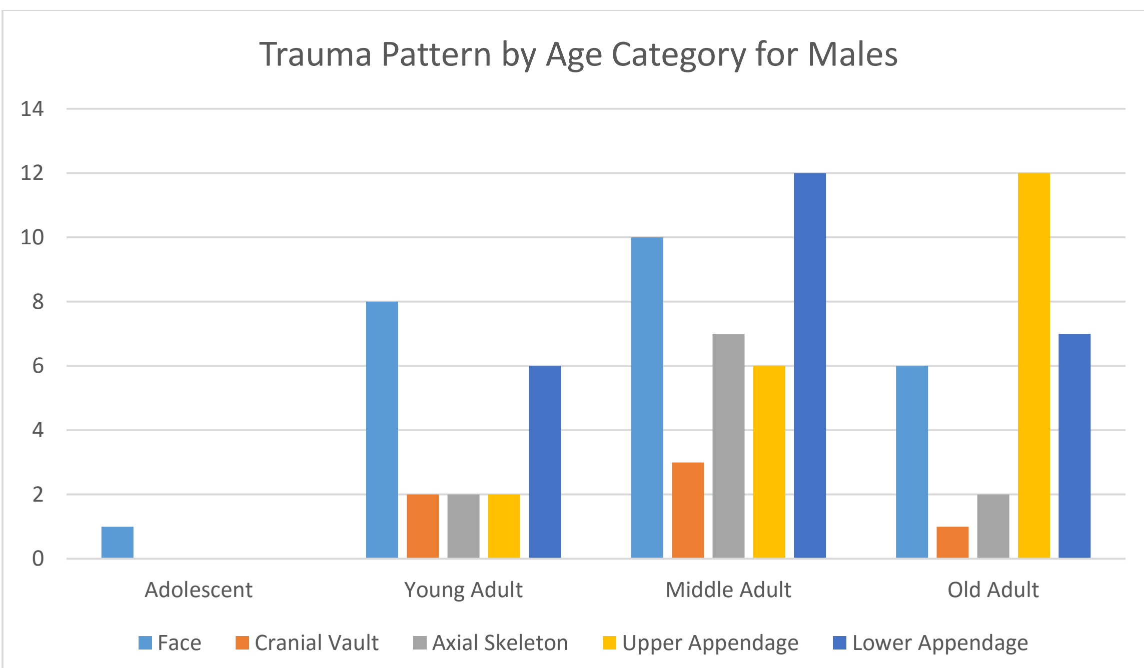

Figure 17. Injury Patterns by Age Category for Arikara Male

Applying a generalized linear model to the data and comparing the intercept of sex and age, with Old Adult males serving as the reference category and trauma as the dependent variable, the following results were observed: (1) Young and Middle Adult males had significantly lower rates of trauma compared to Old Adult males (p=0.006 and p=0.031, respectively), (2) Young and Middle Adult females also had significantly lower rates of trauma (p=0.000 and p=0.001, respectively), (3) Old Adult females did not have a significantly different level of trauma when compared to Old Adult males (p=0.329). Collectively, the frequency of traumatic injuries increased with age, regardless of sex (Figure 18). As would be expected, injuries accumulate with age in the Arikara sample. While skeletal trauma will heal and remodel, it is never erased from the bone.

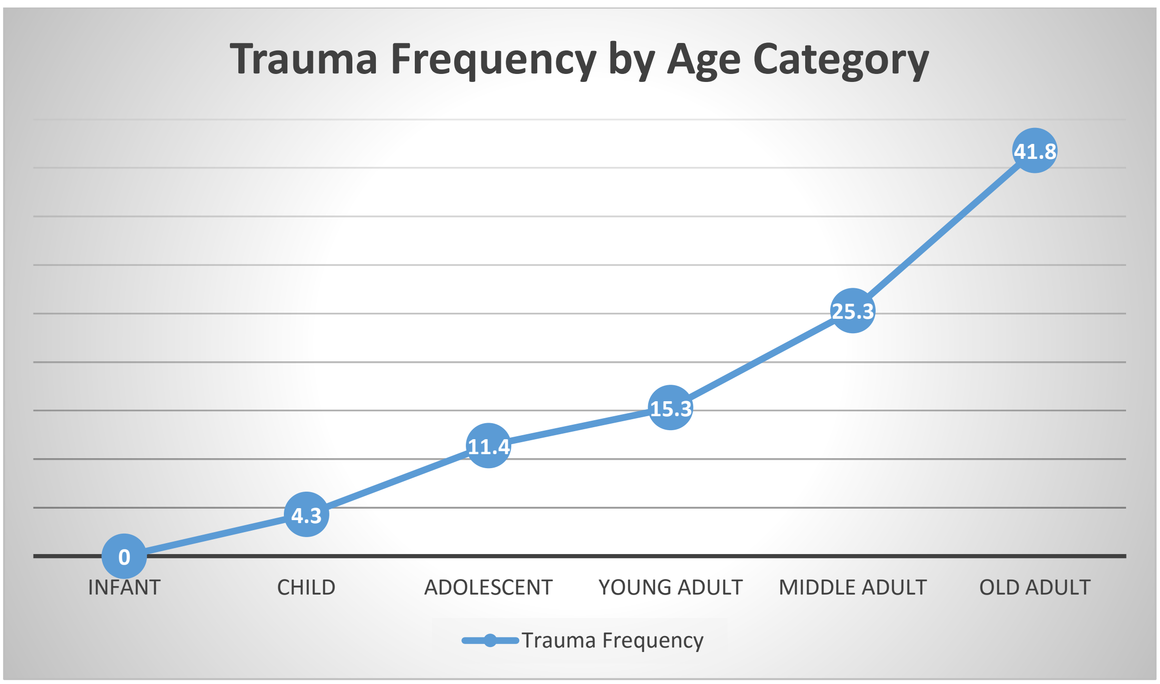

Figure 18. Frequency of Traumatic Injuries by Age Category for the Arikara Sample

While the majority of skeletal injuries were observed in adult remains, there were 20 incidents of traumatic injury in subadult remains: 6 Children and 14 Adolescents (Tables 8 and 9).

Table 8. Traumatic Injuries in Arikara Children

Age	Trauma Description
11-12 yrs.	Fractured nasals
5-7 yrs.	Rib fractures
4-6 yrs.	Fracture of the radius
9-10 yrs.	Fracture to distal femur
7.5-8.5 yrs.	Depressed cranial fracture
5-7 yrs.	Depressed cranial fracture (possible probe hole) *

*All injuries are antemortem, except those marked with an asterisk denoting them as perimortem.

The frequency of trauma in Children was 4.3% (6/139). The frequency of trauma in Children was lower than any other age category, except Infants which exhibited no trauma. Again, this finding highlighted the cumulative nature of injuries within the Arikara sample, where individuals tended to accumulate injuries with increased age. It is also worth noting that no Arikara Children sustained lethal injuries, with the exception of the 5-7-year-old child exhibiting a "perimortem" cranial fracture. In Osteoware, the data recorder stated that the injury may have resulted from a probe during excavation of the site. After viewing the associated photograph, this injury was excluded from the sample of perimortem injuries as it appeared to be postmortem in nature (Figure 19).

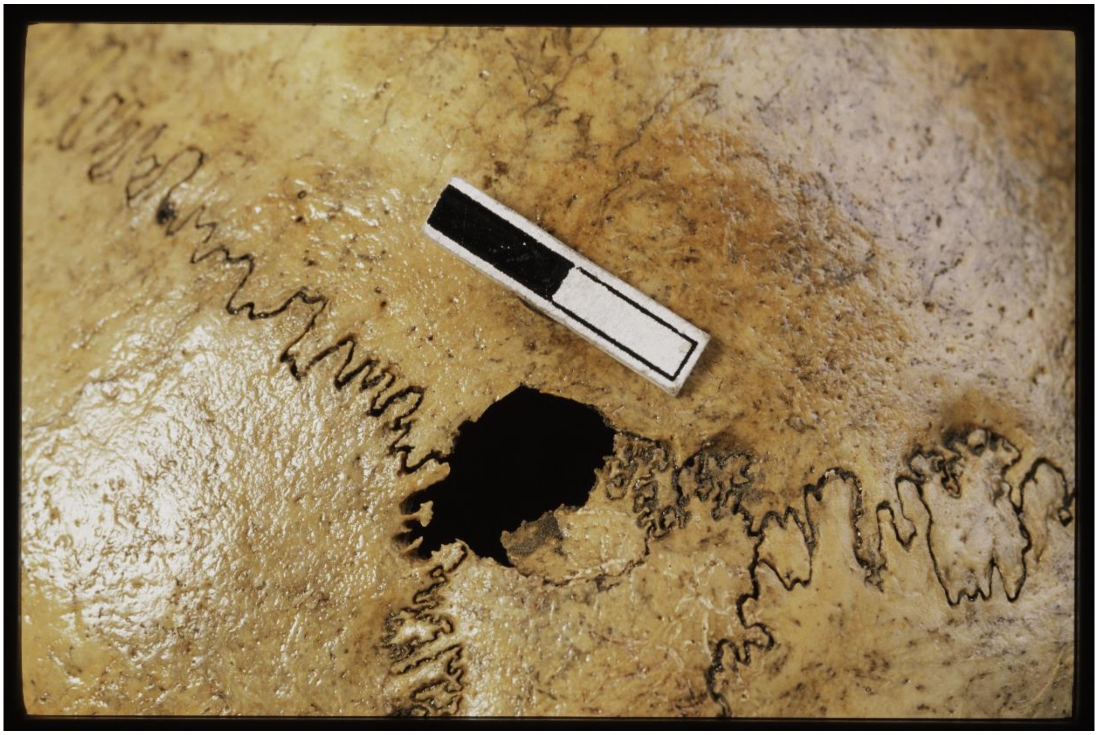

Figure 19. Cranial Fracture Recorded as a Possible Perimortem Fracture or Postmortem Injury Resulting from a Probe During Excavation. Child, Age 5-7 Years from the Sully Site

Table 9. Traumatic Injuries in Arikara Adolescents

Age	Sex	Trauma Description
11-14 yrs.	Indeterminate	Cut marks consistent with scalping*
11-13 yrs.	Indeterminate	Fractured nasals
13-14 yrs.	Indeterminate	Projectile point embedded in calcaneus
16-18 yrs.	Female	Fractured nasals
15-18 yrs.	Female	(1) Cut marks consistent with scalping*; (2) Depressed cranial fracture
17-21 yrs.	Female	Depressed cranial fracture
17-20 yrs.	Female	Depressed cranial fracture
15-19 yrs.	Female	Rib fracture
~18 yrs.	Female	Fractured clavicle
18-21 yrs.	Female	(1) Fractured clavicle; (2) Fractured metacarpal
15-19 yrs.	Female	Cut marks consistent with scalping
17-21 yrs.	Female	Fractured rib
18+	Indeterminate	Fractured metatarsal
17-19 yrs.	Male	Depressed cranial fracture

*All injuries are antemortem except those marked with an asterisk denoting them as perimortem.

The frequency of trauma in Adolescents was 11.4% (14/123) (Table 9). For Adolescents whose sex could be determined, the pattern of injury was similar to the pattern observed in Adults, with females exhibiting a high frequency of depressed cranial fractures. Notably, the majority of injuries in Adolescents of a known sex occurred in females; only one Adolescent male displayed trauma.

Temporal Differences (Pre- versus Post-Contact)

The temporal analysis revealed varying levels of trauma in the Pre-Contact and Post-Contact periods. In the Pre-Contact period, the frequency of trauma was 17.8% (42/236), while the frequency of trauma in the Post-Contact period was 11.0% (82/744). This change over time was statistically significant (χ^2=7.441; *df*=1; *p*=0.006) with the frequency of trauma decreasing from the Pre-Contact to the Post-Contact period. When assessed by sex no significant difference in trauma frequency was observed in males by contact periods (χ^2=2.778; *df*=1; *p*=0.096). Females had a significantly higher frequency of trauma in the Pre-Contact period than in the Post-Contact period (χ^2=4.283; *df*=1; *p*=0.038). The regions of the body affected by trauma did not change from the Pre-Contact to the Post-Contact period, with the exception of injuries to the splanchnocranium and upper appendage in males. As shown in Figure 20, males had a much higher frequency of facial injuries and upper appendicular injuries in the Post-Contact period than the Pre-Contact period. While both cranial injuries and parry fractures were observed in the male sample, no single Arikara male exhibited both injuries simultaneously. The pattern of trauma in females in the Post-Contact period directly mirror the pattern observed in the Pre-Contact period (Figure 21).

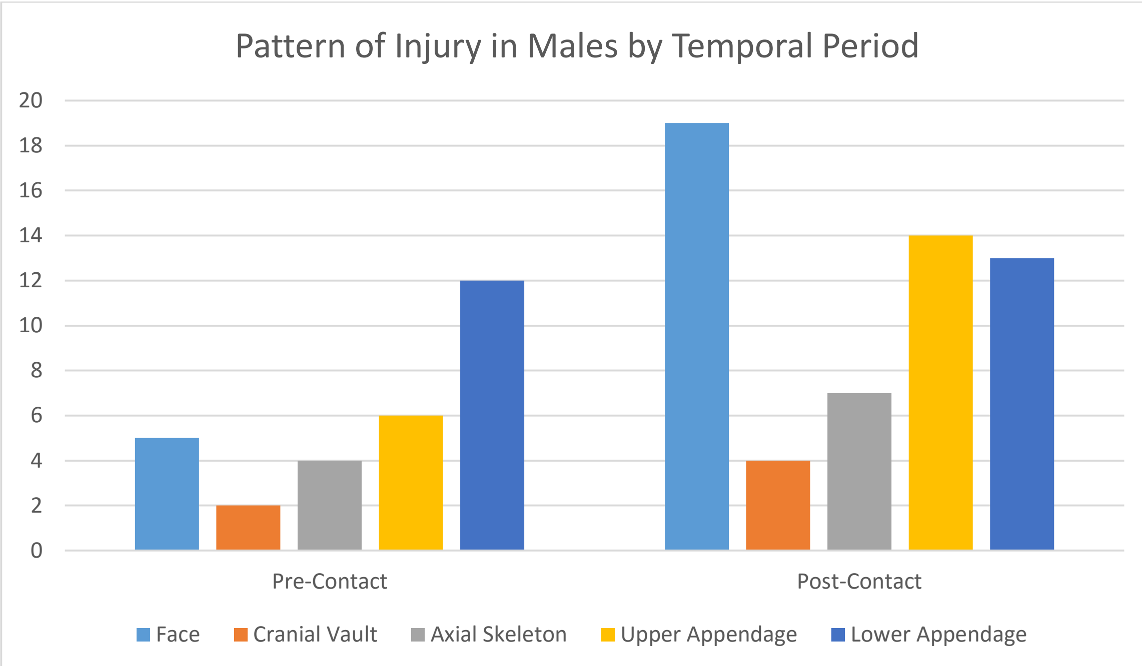

Figure 20. Pattern of Injury by Body Region for Males in the Pre- and Post-Contact Periods

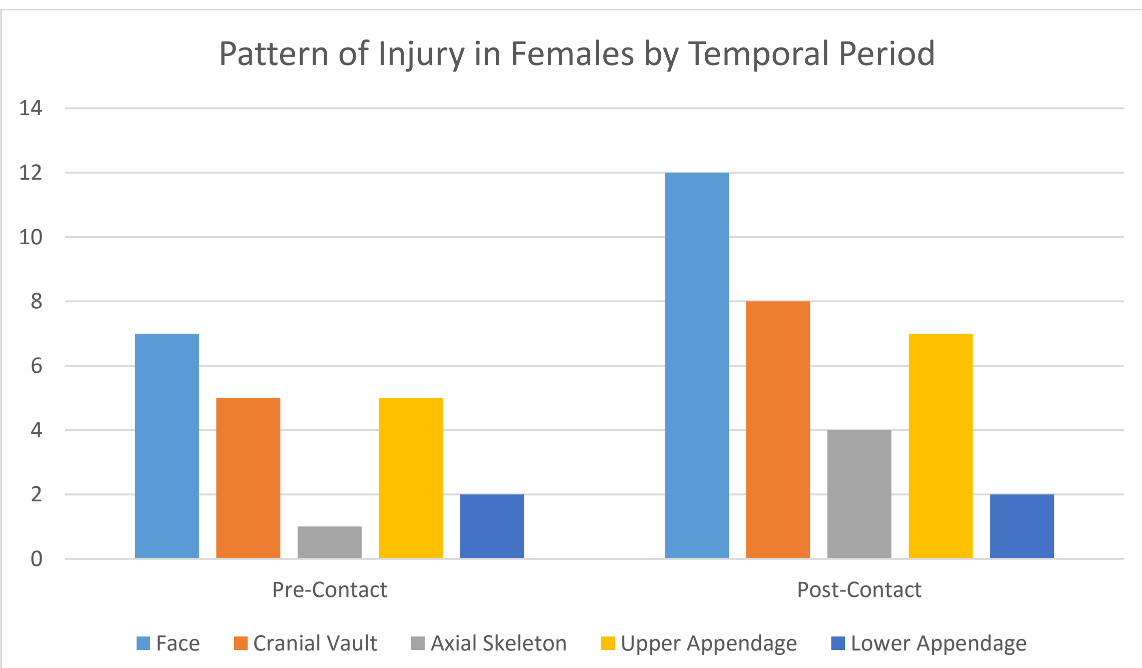

Figure 21. Pattern of Injury by Body Region for Females in the Pre- and Post-Contact Periods

To assess change over time, the sample was divided into two temporal groups, Pre-Contact (Extended Coalescent variant) and Post-Contact (Post-Contact Coalescent variant), using the classification system of dividing the Coalescent into three variants: Initial, Extended and Post-Contact. According to Lehmer's (1971) taxonomic system, the Coalescent tradition can instead be divided into four variants: Initial, Extended, Post-Contact, and Disorganized Coalescent. Following Lehmer's (1971) classification system, the Leavenworth Site would be classified as Disorganized Coalescent. For the purposes of this research, the Disorganized Coalescent variant was absorbed into the Post-Contact Coalescent, preventing a diminished sample size in the Disorganized Coalescent variant. However, if Leavenworth, as the only historic site included in the sample, is analyzed independently, an interesting pattern and frequency of trauma emerges.

Within the SI Arikara sample there were thirty individuals associated with the Leavenworth Site. Human skeletal remains curated at the SI were excavated from the associated cemeteries, the village, houses, and refuse heaps during four field seasons led by William H. Over, Matthew W. Stirling, and William Duncan Strong (Billeck et al. 2005). Of the thirty individuals from Leavenworth, seven individuals displayed trauma on their skeletons (23.3%): three females, one male, two adolescents and one child. Interestingly, each of the seven individuals with skeletal trauma displayed at least one skeletal marker of interpersonal violence (Table 10). The Disorganized Coalescent yields a markedly elevated frequency of trauma (23.3%) than was observed in the original Pre-Contact (Extended Coalescent variant; 17.8%) and Post-Contact (Post-Contact Coalescent variant; 11.0%) temporal classification system.

Table 10. Trauma at the Leavenworth Site

Age Category (Age Range)	Sex	Trauma Description
Child (11-12 yrs.)	Indeterminate, subadult	Fractured nasals
Adolescent (11-13 yrs.)	Indeterminate, subadult	Fractured nasals
Adolescent (11-14 yrs.)	Indeterminate, subadult	Cut marks consistent with scalping*
Adult (30-35 yrs.)	Female	(1) Fractured nasals; (2) Oval penetrating defect on occipital squama consistent with sharp force trauma
Adult (45-55 yrs.)	Female	(1) Fractured nasals; (2) Fracture of left maxilla; (3) Fracture of distal right radius; (4) Sharp or blunt force cranial fracture
Adult (35-40 yrs.)	Female	(1) Fracture of 1st sacral segment; (2) Depressed cranial fracture of left parietal
Adult (35-45 yrs.)	Male	Two depressed cranial fractures on the frontal bone

*All injuries are antemortem except those marked with an asterisk denoting them as perimortem.

Regional Differences (Bad-Cheyenne vs. Grand Moreau)

When the sample was divided geographically, 575 individuals came from the Bad-Cheyenne region and 415 individuals from the Grand-Moreau region. In the Bad-Cheyenne region the frequency of skeletal trauma was 13.2% (76/575), while the frequency in Grand-Moreau was 11.8% (49/415). In regards to geographic distribution, there was not a statistically significant difference in the frequency of trauma by region (χ^2=0.434; *df*=1; *p*=0.510).

INTERPERSONAL VIOLENCE

To further delineate the social interactions of the Arikara living in the Missouri River Basin during the Extended Coalescent and Post-Coalescent variants, the study assessed the frequency of three skeletal markers indicative of interpersonal violence: (1) craniofacial and cranial vault injuries, (2) projectile or bladed weapons trauma, and (3) evidence of mutilation (i.e. scalping).

Craniofacial Trauma

The sample yielded 44 adult individuals with craniofacial trauma, including 19 females (10.8%, 19/176) and 25 males (12.8%, 25/196), a non-significant difference between the sexes (X^2=0.341; *df*=1; p=0.559). Craniofacial injuries were also observed in subadults on two occasions (one Adolescent and one Child). The highest prevalence of craniofacial injuries was observed in Old Adults (18.2%, 12/66), followed by Middle Adults (15.6%, 14/117), and then Young Adults (12.2%, 16/131). The difference in the prevalence of craniofacial injuries when comparing adult age groups was non-significant (X^2=1.669; *df*=2; p=0.434).

When comparing the Extended Coalescent and the Post-Contact Coalescent variants, the frequency of craniofacial trauma remained constant with 6.3% (12/190) showing evidence of craniofacial trauma in the Pre-Contact period and 7.1% (33/462) with craniofacial trauma in the Post-Contact period, again a non-significant difference (X^2=0.143; *df*=1; p=0.705). When the sample was subdivided by region, 6.3% (23/366) of individuals from the Bad-Cheyenne had craniofacial trauma, while 7.8% (23/294) of individuals from the Grand-Moreau region exhibit craniofacial trauma, another non-significant difference (X^2=0.596; *df*=1; p=0.440).

Cranial Vault Trauma

Twenty individuals manifested cranial vault injuries, including 11 females (6.3%, 11/176), six males (3.1%, 6/196), and three subadults. Although nearly twice as many females as males had cranial vault injuries, the difference was still non-significant between the sexes (X^2=2.162; *df*=1; p=0.141). The highest prevalence of cranial vault injuries was observed in Old Adults (4.5%, 3/66), followed by Middle Adults (4.9%, 5/118), Adolescents (3.9%, 3/76), Young Adults (3.8%, 5/131), and finally Children (2.2%, 2/89). The difference in the prevalence of cranial vault injuries was found to be non-significant (X^2=0.7578; *df*=4; p=0.944011).

When comparing the Extended Coalescent and the Post-Contact Coalescent variants, the frequency of cranial vault trauma stayed relatively constant with 3.7% (7/190) showing evidence of cranial vault trauma in the Pre-Contact period and 2.8% (13/462) with cranial vault trauma in the Post-Contact period, again a non-significant difference (X^2=0.343; *df*=1; p=0.558). When the sample was subdivided by region, 3.6% (13/366) of individuals from the Bad-Cheyenne have cranial vault trauma, while 2.4% (7/294) of individuals from the Grand-Moreau region exhibit cranial vault trauma, another non-significant difference (X^2=0.731; *df*=1; p=0.380).

Projectile and Bladed Weapons Trauma

Ten individuals had projectile or probable weapon-related injuries, including two females (0.83%, 2/242), seven males (2.6%, 7/266) and one adolescent (0.81%, 1/123). The sex distribution of projectile and weapon injuries was not significantly different (Fisher's exact, p=0.112), although males were more than three times as likely to exhibit projectile or weapon-related injuries. The highest prevalence of weapon injuries occurred in Young Adults (2.7%, 5/183), followed by Middle Adults (3/174), one Old Adult (1/79), and one Adolescent with an embedded projectile point (1/123).

Comparing the Extended Coalescent and the Post-Contact Coalescent variants, the frequency of weapon-related trauma increased from 0.4% (1/236) in the Pre-Contact period to 1.2% (9/741) in the Post-Contact period, again a non-significant difference (Fisher's exact, p=0.263). When the sample is subdivided by region, 0.9% (5/575) of individuals from the Bad-Cheyenne have cranial vault trauma, while 1.2% (5/415) of individuals from the Grand-Moreau region exhibit weapons trauma, another non-significant difference (Fisher's exact, p=0.415).

Trophy Taking

Four individuals showed evidence of mutilation and trophy taking. One individual had drill holes in the right temporal and malar, indicating a possible trophy skull. The possible trophy skull belonged to a male aged 30-49 years. The other three incidences of trophy taking were scalping cuts and a healing scalping. Two of the individuals with evidence of scalping were females, and one was of an indeterminate sex due to the young age of the individual (11-14 years of age). All three individuals that exhibited evidence of scalping were Adolescents, aged 11-14 years, 15 to 18 years, and 15 to 19 years, respectively.

Two of the scalped individuals were attributed to the Extended Coalescent period while the third was attributed to the Post-Contact Coalescent variant. Two individuals came from the Grand-Moreau region (one Pre-Contact and one Post-Contact) and the third individual was from the Bad-Cheyenne region. The trophy skull was dated to the Post-Contact Coalescent variant and was excavated from the Bad-Cheyenne region.

Summary of Interpersonal Violence in the Arikara Sample

When all skeletal indicators of interpersonal violence are combined, there is not a significant difference in the frequency of interpersonal violence comparing males and females (X^2=0.817; *df*=1; p=0.366). Neither is there a significant difference when comparing the temporal variants (X^2=1.068; *df*=1; p=0.301). These results lead to the conclusion that the differences in frequency of skeletal trauma between the sexes and temporal variants result from injuries acquired accidentally, or in ways that cannot definitively be associated with interpersonal violence. When comparing the frequency of traumatic injuries not associated with violent human interactions, a significant difference occurs between the Pre-Contact and the Post-Contact period (X^2=8.985; *df*=1; p=0.003), with a higher frequency of non-violent trauma in the Pre-Contact period.

SIOUX COMPARATIVE SAMPLE

To address the social interactions through time and in different regions of the Missouri River Basin during the Post-Contact Coalescent variant, the study assessed the frequency of skeletal markers indicative of interpersonal violence in Sioux skeletal remains. The Sioux are an equestrian tribe with frequent interactions with the Arikara tribe in the Post-Contact Coalescent (Makseyn-Kelley 1999). Sioux skeletons are affiliated with the Oglala and the Brule. Because the skeletal remains are biased toward cranial remains (only 19 of the 77 individuals had post-cranial remains), comparisons were only drawn from frequencies of craniofacial trauma and cranial vault trauma. Of the 77 Sioux crania, 13 individuals manifested evidence of cranial trauma (16.9%).

Craniofacial Trauma

Nine adults exhibited evidence of craniofacial trauma, including two females (8%, 2/25), six males (16.2%, 6/37), and one individual of an undetermined sex. Differences between the sexes were non-significant (Fischer's exact, p=0.456). The highest prevalence of craniofacial injuries was observed in Old Adults (36.4%, 4/11), followed by Middle Adults (15.8%, 3/19), and then Young Adults (2%, 2/30). The difference in the prevalence of craniofacial injuries by adult age groups was non-significant (Fischer's exact, p=0.076).

Cranial Vault Trauma

Six individuals manifested cranial vault injuries, including five males (13.5%, 5/37) and one individual of an undetermined sex. The highest prevalence of cranial vault injuries was observed in Middle Adults (10.5%, 2/19), followed by Young Adults (10%, 3/30), and Old Adults (9%, 1/11). The difference in the prevalence of cranial vault injuries was non-significant (Fischer's exact, p=0.763).

No cranial injuries were noted on skeletal remains from individuals under the age of 16 years (one Adolescent male was recorded as having a craniofacial injury). Additionally, four perimortem cranial injuries were observed in the Sioux sample, including one individual with evidence of shotgun pellets to the frontal and left parietal. All perimortem injuries occurred in males.

Summary of Sioux Comparative Sample

When compared to the Arikara sample, the pattern of injury observed in the Sioux is comparable for craniofacial injuries, with males exhibiting a higher frequency of craniofacial injuries. However, the pattern of injury is reversed when comparing cranial vault trauma, with Arikara females twice as likely to exhibit cranial vault trauma as Arikara males, while not a single cranial vault injury was observed in the female Sioux sample. In both samples, perimortem injuries were observed more frequently in males.

EXCAVATOR BIAS

Several sites included in this research were excavated on multiple occasions by different archaeologists. References to excavator bias were noted in records curated at the NAA as well as previous site reports. Billeck et al. (2005:49-50) state that "Stirling generally did not collect the skeletal remains of infants or poorly preserved skeletal remains." Similarly, Bass et al. (1971:19) suggest, that while difficult to document, it is probable that in Stirling's excavations of the Leavenworth Site, he collected cranial remains and left the remaining postcranial materials and infants skeletal remains in the field. To assess excavator bias in the Arikara sample, bias was assessed using skeletal remains recovered from the Mobridge Site (Table 11).

Table 11. Summary of Human Remains Recovered from the Mobridge Site by M. Stirling (1923) and T.D. Stewart and D. Ubelaker (1971)

Skeletal Elements Recovered	Excavator (year)	
	Stirling (1923)	Stewart & Ubelaker (1971)
Crania Only	9 (23%)	4 (1.2%)
Post-crania Only	5 (12.8%)	92 (27.5%)
Complete Skeleton	20 (51.3%)	167 (50%)
Fragmentary Remains	5 (12.8%)	71 (21.3%)
Total	39	334

Comparing the frequency of skeletal remains recovered by body region (i.e., crania only, post-crania only, complete skeleton, or fragmentary remains), Stirling recovered a significantly higher than expected frequency of cranial remains than were recovered in the subsequent excavation conducted by Stewart and Ubelaker (X^2=52.1; *df*=3; p<0.00001). The results of this test corroborate the suggested bias outlined by Bass et al. (1971) and Billeck et al. (2005).

Skeletal materials from the Mobridge Site were also subdivided according to age category and comparisons were drawn between the demographic profile of the samples excavated by Stirling and Stewart and Ubelaker (Table 12).

Table 12. Age-at-death for Skeletal Remains Recovered from the Mobridge Site by M. Stirling (1923) and T.D. Stewart and D. Ubelaker (1971)

Age of Skeletal Remains	Stirling (1923)	Stewart & Ubelaker (1971)
Fetal	0 (0%)	6 (1.8%)
Infant	1 (2.6%)	114 (34.1%)
Child	1 (2.6%)	52 (15.6%)
Adolescent	6 (15.4%)	33 (9.9%)
Adult	3 (7.7%)	20 (6.0%)
Young Adult	14 (35.9%)	45 (13.5%)
Middle Adult	10 (25.6%)	49 (14.7%)
Old Adult	4 (10.3%)	15 (4.5%)
Total	39	334

A chi-square test again highlighted a bias when comparing Stirling's and Stewart and Ubelaker's excavation materials. The frequency of Infant and Child remains was significantly lower than expected in the 1923 sample when compared to the 1971 sample (X^2=33.359; *df*=7; p<0.00001), suggesting that Stirling preferred collecting adult materials while omitting infants and children.

Summary of Excavator Bias

The results of this research indicate that a number of biases exist when working with archival data. Biases associated with sampling methods and inadequate sample sizes are just two of the biases outlined in this research. Excavator biases were likely compounded by the nature of the RBS Program, where sites were excavated on multiple occasions by different archaeologists. Recognition, cautious interpretation and more detailed exploration of biases in archival datasets are topics for future research.

CHAPTER 9: DISCUSSION

Implementation of repatriation legislation at the SI prompted anthropologists to consider the loss of knowledge that would occur with the repatriation of Native American remains and associated artifacts. Although a large number of the skeletal remains are still curated at the museum, repatriation policy at the SI requires explicit consent from the tribe before scientists and researchers are given access to the skeletal collections. Absence of tribal consent has the same result for scientific research as reburial. The impetus for the present research was to test the hypothesis that data recorded from SI collections subject to the NMAIA could be used to conduct bioarchaeological research. As noted in the previous chapter, working with the SI repatriation data and RDBMS was, in large part, a success. The results of this study provided empirical support that it is possible to conduct original research using the osteological data collected from repatriated collections. The shortcomings and disadvantages of working with the SI RDBMS were outlined in the results section and will be further discussed in this chapter. Additionally, there were an even greater number of benefits to working with the SI collections that will be outlined, followed by a discussion of the future of digitized archival data in anthropology. The last section of the discussion will focus on the results of the Arikara trauma analysis.

DATA ACCESSIBILITY

Most complications of working with the SI's osteological data were minor and could easily be resolved with minimal time investment and minor edits to the inventory and pathology modules. However, one complication of working with the osteological database warrants further discussion: namely the lack of integration of mortuary, photographic and radiographic data with the osteological database.

Following enactment of the NMAIA in 1989, the SI devoted much time and many resources into collecting digital osteological data. The creation of *Standards* for the collection of osteological data served a dual purpose in the ROL. First, *Standards* imposed protocols for efficient and effective data collection, while increasing comparability among skeletal collections. Second, in following *Standards,* ROL employees were collecting the osteological data necessary for establishing cultural affiliation. The development of Osteoware provided standard osteological protocols for the SI data collection process and increased the comparability of data collected by different analysts, while simultaneously decreasing inter-observer error through use of the Osteoware GUIs. Development of standard protocols for the collection of osteological data was a relatively straightforward process, because each skeleton was composed of a limited number of elements and osteological data had been collected previously on a limited, albeit expanding, number of variables. Unlike osteological data, mortuary artifacts are less amenable to the development of standards of data collection because of the variability and differences of opinion related to artifact interpretation. Even so, the SI is in the process of developing standards of data recording from archaeological collections (Dr. Torben Rick, personal communication on September 15, 2015). In the early 1990s the SI developed databases for the curation of data pertaining to mortuary artifacts, burial provenience, etc. (Dr. William Billeck, personal communication on March 29, 2016). However, the osteological database has not been linked with the databases containing artifact and burial provenience data. Burdened with repatriation requests and time constraints on the assessment of human skeletal remains, the ROL ceased its efforts to establish digital collections of Native mortuary artifacts in the mid-1990s because the staff was not integrating mortuary data into their assessment reports and the databases were not viewed as a critical component of the repatriation process (Dr. William Billeck, personal communication on March 29, 2016). Currently, the ROL is updating their records of Native American artifacts and all SI database holdings are being moved to a Research and Collections Information System known as EMu (SI 2016). While efforts are underway to update the EMu system, the present research was limited by an inability to link the artifact and mortuary data with the osteological data, thereby limiting interpretations of the SI osteological data.

Bioarchaeological research traditionally contextualizes acts of violence through insights gleaned from both osteological analysis and the material record, including mortuary context and funerary items. One of the most challenging aspects of evaluating skeletal trauma is determining the etiology of the injury. There are many reasons why an individual, or multiple individuals, would incur skeletal injury: military or warfare activities, inter-personal violence, accidents, workplace or occupational injuries, etc. (Filer, 1997). Distinguishing between these different activities and causes for traumatic injury is one of the primary difficulties faced by a bioarchaeologist (Jurmain 1999). For example, a depressed cranial fracture may have been incurred during a war or battle, but the fracture may also have occurred during an inter-personal conflict or an accident. The mortuary context of this individual's burial—intentionally placed body, burial shroud or other body coverings, weaponry, grave offerings, etc.—may suggest that this individual was a warrior who participated in a battle. The direct cause of the injury can be assessed based on the mechanical properties of bone and the diagnostic features of fractures (i.e. the fracture patterns produced by blunt and sharp force trauma; Walker 2001). However, the cultural context of the injury must also be reconstructed. Determination of an injuries 'ultimate cause' requires detailed consideration of both intrinsic biological variables, such as age and sex, and extrinsic factors, relating to the physical and sociocultural context, including mortuary context (Walker 2001:578). Thus, biological and cultural information must be interpreted simultaneously to establish the most probable cause of injury—hence the value of a bioarchaeological approach. Using the SI data, data pertaining to intrinsic biological variables is readily available. However, the extrinsic factors, including mortuary context, burial provenience and funerary items are not associated with the osteological data and therefore simultaneous interpretation of biological and archaeological data is not tenable using the SI osteological database.

The ROL has developed a highly effective and accessible database of osteological data, and a consistent method of recording for human remains. However, the lack of association between the osteological data and databases for funerary objects, sacred objects, and contextual and mortuary information is an issue that has been raised repeatedly by the Repatriation Review Committee since the early 1990s (Goldstein and Anyon 2005). The implementation of standard protocols for the recording of data from artifacts, sacred objects, and contextual information would serve to strengthen interpretations of the osteological record and enable future researchers to utilize the SI data for bioarchaeological research. In their current form, the SI repatriation data is useable for an analysis of trauma following a paleopathology model, however, the data lacks the contextual information necessary to conduct a full-scale bioarchaeological analysis. Without the associated provenience and archaeological data, trauma was best interpreted according to the pattern of injuries. Wound patterns were interpreted based upon different patterns of injury observed between different age and sex categories, geographic regions, and between temporal periods (Pre- vs. Post-Contact). Divorced from the mortuary and archaeological record, interpretation of the osteological data is uncertain at best. Therefore, interpretations of violence in the Arikara sample used in the present research are limited in what can be said regarding the significance of skeletal trauma (i.e. accidental injury or intentional trauma) or why trauma occurred (i.e. warfare, ritualistic practice, domestic abuse, environmental stressors).

It must be recognized, that the lack of artifact and contextual information is not entirely a reflection of the SI data recording methods, but in large part the result of the RBS salvage archaeology. The majority of skeletal remains used in this research were collected under the auspices of the RBS, and as such, the skeletal collections did not always yield an accurate representation of the site's population. Some of the skeletal remains were also unintentionally uncovered in the 1950s. For example, burials at the Leavitt Site were unintentionally disturbed by the construction of a road in 1954 (Billeck et al. 2005). Richard P. Wheeler, on behalf of the RBS, collected the remains disturbed during road construction, however, the burials could not be recorded *in situ*. In 1955, the Lytle and Green Construction Company, while mining for fill dirt for the Oahe Dam, disrupted a number of burials in the Buffalo Pasture cemetery (Billeck et al. 2005). Subsequent attempts to locate the disturbed burials *in situ* were unsuccessful. Finally, artifact provenience was often not recorded. During Stirling's 1923 excavations of Leavenworth, Nordvold 1, Nordvold 2/3 and Mobridge, many objects could not be identified to specific sites and burial contexts (Billeck et al. 2005). In the future, it is recommended that standardized databases for artifacts, sacred objects, and contextual information be developed and linked to the osteological database when these data are available.

A similar issue was uncovered when working with the photographic and radiographic materials associated with the Arikara skeletal collections. While Osteoware allows the data recorder to request supplementary photographic and radiographic documentation of all skeletal elements, these supplemental materials are stored in a separate system, or have not yet been digitized. A number of digital images were stored in EMu and in a shared drive for the ROL, but the majority of photographs and radiographs have yet to be digitized and had to be obtained directly from the ROL and physical anthropology collections at the Museum Support Center. Additionally, many of the photographs and radiographs for the Arikara sample did not adequately display the trauma recorded in Osteoware. A lack of systematized documentation of photographic and radiographic materials limited the authors ability to corroborate the qualitative data recorded in Osteoware. Standards for photographs and radiographs should be developed and enforced as another means of preserving our knowledge of past populations. Developing standards for these supplemental materials would provide a method of assessing inter-observer error between past data collectors, as well as providing another form of primary data to help correct interpretative errors in the past. Digitization and integration of photographic and radiographic documentation would also alleviate issues of calculating element frequencies in the collection. As presented in the results section, calculating a "percent complete" for an entire cranium or for post-cranial elements was an inaccurate and time-consuming process. The integration of photographic documentation would provide researchers a visualization of the skeletal element(s). The addition of an image of each skeleton in anatomical position would provide an overview of the remains to be used in assessments of preservation and skeletal completeness.

In summary, the results of this research suggest that the ROL has developed a highly effective and accessible database of osteological data and a consistent method of recording for human skeletal remains. The osteological data can be quickly and easily isolated, exported, manipulated and analyzed. The one shortcoming of the osteological data is a lack of standardization in the photographic and radiographic images. In the future, standards should be developed for all photographic and radiographic images and these materials should be curated with the osteological data or in an associated database.

To a certain extent, the SI repatriation data were useable for original research, however, the lack of association between the osteological data and archaeological and contextual burial data proved a hindrance to performing bioarchaeological research using only the SI digitized collections. While archaeological and mortuary data were not always available, the archaeological data that was collected and burial provenience (when know) should be standardized and linked to the osteological database. Integrating archaeological and contextual information would serve to strengthen interpretations of the skeletal remains and allow for a bioarchaeological approach to studying past people.

DIGITIZED DATA IN ANTHROPOLOGY

The Benefits of Working with Large-Scale, Digitized Data

While there were minor complications in accessing the SI data, and a lack of integration of the osteological data with provenience and artifact data, working with the SI osteological RDB and RDBMS proved successful. The efforts undertaken by the SI in the early 1990s through the present go unparalleled and the Institution has demonstrated the importance of preserving our skeletal record of the past. With the development of *Standards* and the creation of Osteoware, the SI has preserved and made available large-scale databases to be used by future researchers now that repatriated collections are no longer accessible. The creation of large-scale databases will change the way we conduct bioarchaeological research.

Digital osteological databases present new and exciting opportunities for the field of anthropology. One of the biggest advantages of working with an osteological database is the durability of the data. Osteological databases do not suffer from the deteriorative effects of time that skeletal remains are subject to. Skeletal remains risk damage and loss from repetitive handling, carelessness of researchers and students working with the materials, transportation of collections, and inappropriate curation environments. The data collected from skeletal collections, however, has proven to be long-lasting. Unlike skeletal materials or paper datasheets, digitized osteological data provides a stable resource for current and future analysis. Digitized bioarchaeological data are not only more durable than fragile skeletal materials or paper forms, relational databases themselves have proved to be substantially more secure and reliable than other digital forms of curating data (i.e. Excel, Quattro Pro, Lotus, Google Sheets, etc.; Keller 2009). Unlike spreadsheets, relational databases are designed to be efficient at data management and manipulation. In a relational database environment data are always meaningfully related and cannot be unintentionally disassociated as would be the case in a spreadsheet, when a single column is sorted independently of all other columns (Keller 2009:26-27). Data storage is also less susceptible to corruption in a relational database, and the structure inherently promotes the storage of associated metadata. Metadata provides information related to one or more aspects of the curated data, including time of creation, data recorder information, standards used, and in cases of photographic and radiographic images, file size and resolution.

In addition to the durability of digitized data, working with digitized data in a relational database allows the researcher to expand the research focus with minimal time investment. As an example from the present research, this study expanded the sample size by nearly 80 individuals using a simple SQL query. The author included a sample of Sioux skeletal remains to make comparisons between two roughly-contemporaneous Native American tribes inhabiting the Middle Missouri River Basin. In two hours the author was able to export, clean, normalize, and analyze the Sioux data for comparison with the trauma frequency data compiled for the Arikara tribe. The addition of Sioux expanded the geographic scale of the analysis, the sample size, and the breadth of the analysis.

The Future of Archival Data in Anthropology

Historically, anthropological research has utilized traditional data collection methods, which involve independent analysis and data collection from existing skeletal collections. In a university or museum setting, a collection may be analyzed and have data recorded dozens, if not hundreds of times. The traditional method of data collection begs the question: is re-analysis and independent data collection necessary? Enactment of repatriation legislation has forced this question as access to skeletal collections is drastically reduced by the reburial of human skeletal remains or constraints placed upon collections following the offer of repatriation. What this study demonstrated is that re-analysis and independent data collection of osteological data is not a necessary component of an anthropological research design. The development of *Standards* provided a means of ensuring comparability of data collected by different institutions and individuals, and increased the percentage of skeletons analyzed in the United States from roughly 30% to nearly 100% (Rose et al. 1996). *Standards* also minimized inter-observer error as researchers are prompted to utilize generalized categories of data collection instead of independent analysis without standard protocols. Most importantly to this research, repatriation prompted the development of relational databases for the curation of osteological data, which allow current and future researchers to assess the work of our predecessors. While the curation of digitized osteological data is becoming more commonplace in physical anthropology, practitioners have yet to maximize potential extraction and manipulation of data curated in relational databases.

Traditionally, data mining and working with relational databases has been an impediment to anthropological research because anthropologists are not typically trained in data mining and SQL code writing. Instead, researchers using the SI collections for research have emailed the ROL manager to request a subset of the SI data. Without a working knowledge of the SI collections, the researcher is working blind. The laboratory manager can provide the requested data, however, the researcher is unable to expand their research without sending additional requests to the database manager. This method of hypothesis-driven research minimizes the likelihood of identifying patterns at a macro-regional and –temporal scale. Mining a database can help future researchers to identify previously unknown trends or patterns in the data. As we move from hypothesis-driven research towards exploratory research, we are likely to learn more about a population(s) or see temporal changes that would have not been predicted through reviewing the literature or previous bioarchaeological research. Incorporating data mining methods into anthropological curriculum would eliminate one step in the research process (e.g., requesting data from a lab manager), thereby making our interpretations better-informed, more accurate, and empirically substantiated than was previously possible.

This research has also demonstrated the wide-ranging benefits of employing large-scale datasets and by extension digital relational databases in an assessment of human history. The SI collections represent some of the largest and most variable in the world. Utilization of the SI collections in this research has impacted the insights obtained through an analysis of violence by making readily available large-scale, time-space distributional data that are comparably recorded.

Such large-scale digital samples are easily manipulated and analyzed, a previously unattainable analytical method (Kintigh 2006). The SI database allows researchers to address large-scale and long-term questions with a high level of empirical support because the data spans the entirety of the United States, and a wide range of temporal periods. The development of *Standards* and the integration of standard protocols into Osteoware promoted maximum comparability of data across the sample. Comparability of data allows researchers to integrate data drawn from multiple sites, collectors, and time frames. Data comparability therefore, enables the researcher to identify patterns that become visible in samples larger and more widely geographically and temporally distributed than can be collected by any single individual or at one point in time (Steckel et al. 2002). By increasing the temporal and geographic distributions of samples, we increase the breadth of understanding of the human past; large-scale analyses can reveal changes through time and space, as well as evolving interpersonal interactions between and within populations. In the future, if additional data is desired, a relational database can be expanded to include supplemental analytical tables ensuring that data collection is never a static process.

In the past, large spatial and temporal scale analyses have been inhibited by the complexities associated with archaeological and bioarchaeological data, as well as limited access to primary data (Kintigh 2006). Researchers have been constrained by their abilities to compare their own data-driven results to those of other researchers due to a lack of primary data (Kintigh 2006:570). As a result, they have been forced to draw comparisons with the summary statistics of other projects that smooth over the details of the primary data, potentially minimizing the insights that could be ascertained from a data-driven comparison (Kintigh 2006). The comparability of data collected following *Standards* enhances our abilities to perform data-driven research integrating data from multiple samples drawn from both legacy datasets as well as modern collections. Data mining of large-scale archival datasets can also promote access to primary data. However, many collections in the United States are still largely inaccessible to researchers, either through a lack of digitization efforts or limitations imposed on digitized data (either self-imposed through a lack of knowledge of data mining practices or restrictions through the university or institution). As a field, how do we continue to maximize the use and accessibility of bioarchaeological data for future research?

In 2004, participants in a National Science Foundation-funded workshop titled "Enabling the Study of Long-Term Human and Social Dynamics: A Cyberinfrastructure for Archaeology" concluded that for archaeology to achieve its potential in advancing our understanding of human history, the field must develop an infrastructure to archive, access, integrate, and mine disparate archaeological datasets (Kintigh 2006:567). These principles extend to bioarchaeology as well. The development of *Standards* was the first step in the creation of a nation-wide cyberinfrastructure for anthropological data. The implementation of protocols for anthropological data collection following enactment of repatriation legislation paved the way for the integration of previously disparate datasets. The integration of digital osteological data curated at institutions across the United States and the subsequent mining of these integrated systems will allow us to observe patterns that only emerge in large-scale, widely distributed samples. Bioarchaeological analyses allow us to gain insights on important aspects of human history, such as demography, migration, trade, social interactions, and health on local-to- global scales (Kintigh 2006:570). Traditionally, however, bioarchaeologists have focused on the local scale due to the magnitude of time and financial resources a researcher must invest in data collection.

As an example of the need for a cyberinfrastructure for bioarchaeological data, an issue presented in the results section was the incomplete nature of the skeletal collection. Demography is an essential component of many bioarchaeological analyses and a topic that unfortunately had to be excluded for the present research initiative due to the incomplete nature of the skeletal sample. Although the SI possessed over 18,000 sets of Native American skeletal remains when repatriation legislation went into effect, the samples curated at the museum are still largely incomplete due to the diverse avenues through which the collections were obtained. For example, most Arikara samples were obtained under the auspices of the RBS Program. The RBS excavated a number of sites in the Middle Missouri River Basin. The timing and extensive nature of the RBS program required a large number of archaeologists and archaeological teams. As a result, many sites used in this research were excavated on multiple occasions by different archaeologists. As mentioned in the site summaries and assessed in the results section, some archaeologists performed selective sampling of skeletal remains. For example, Matthew Stirling, while excavating at the Leavenworth Site, generally collected cranial remains, leaving behind postcranial elements and the remains of infants and individuals with poor preservation (Bass et al. 1971:19; Billeck et al. 2005:49-50). This method of selective sampling biased skeletal collections (Bass et al. 1971). Demography may be distorted in some cases due to the selective sampling methods of the excavators (Bass et al. 1971). Excavator biases led to demographic biases in a sample and different in biases arose when sites are excavated by multiple individuals. Similarly, because many sites were excavated on several occasions, the physical remains and associated artifacts, or the data collected from the materials, are now curated at different institutions. Ultimately, this led to the separation of collections between institutions. In addition to the human skeletal remains analyzed by the SI, additional skeletal materials excavated from the ten sites utilized in this research are curated at other universities and institutions. With the development of a bioarchaeological cyberinfrastructure, multiple samples from a single site could be integrated among universities and institutions across the United States leading to broader syntheses of bioarchaeological data. According to Kintigh, and the members of the 2004 NSF-funded cyberinfrastructure workshop, "archaeology's unique ability to provide centennial- and millennial-scale comparative data and comparative data from geographically dispersed areas, [such a knowledge based data-integration system] would allow archaeology to contribute substantially to scientific understanding of long-term social dynamics" (2006:573).

CAUSES OF BIAS IN ARCHIVAL COLLECTIONS

Inter-observer Error

Using the SI repatriation data as a primary source of information highlighted the potential for error when working with archival datasets. As presented in the results section, inter-observer error was assessed through a comparison of the data recorded in Osteoware and the supplementary documentation of trauma in photographs and radiographs. Depressed cranial fractures were visible in only 71% of the cases reported in Osteoware. While it is probable that the injuries were present, this finding reflects the potential for over-estimating trauma frequencies when using archival data. As mentioned previously, standards for photographs and radiographs should be developed and maintained as another means of preserving osteological information. Developing standards for these supplemental materials would provide a method of assessing inter-observer error between past data collectors, as well as providing another form of primary data to help correct interpretative errors in the past. The results of the inter-observer analysis demonstrated the need for cautious interpretation of past populations using archival data. Because the SI repatriation data were recorded by many different observers, and no method of assessing inter-observer error in the sample exists, future analysts must acknowledge the potential for error. In the future, the field of anthropology needs to enhance sources of primary data. Those additional sources include digitized photographs and radiographs, and the integration of three-dimensional imaging or other methods of data recording and visualization with osteological data. The addition of primary sources of skeletal data will diminish interpretative errors made by past data collectors.

Excavator Bias

Recognition of the potential for bias in sampling methods led to an assessment of excavator bias at the Mobridge Site. The results of the excavator bias assessment corroborate the suggested excavator biases outlined by Bass et al. (1971) and Billeck et al. (2005). Through a statistical analysis of the samples collected by Stirling in 1923 and Stewart and Ubelaker in 1971, it was determined that Stirling probably collected cranial elements and adult materials, while discarding the remains of infants and children. It is not known what feature Stirling excavated at the Mobridge Site. However, it is possible that Stirling excavated in Feature 2, the same feature where Stewart and Ubelaker worked 48 years later. A number of the graves excavated by Stewart and Ubelaker in 1971 were disturbed burials. With the assumption that Stewart and Ubelaker collected all skeletal remains discovered at the Mobridge Site, it is possible that the excavations performed in 1971 recovered the remaining post-cranial elements left in the field by Stirling in 1923. This hypothesis was not relevant to the present study of interpersonal violence, and was therefore not explored in great detail.

Another example of bias became evident while working with the Sioux data. Many of the Sioux skeletal materials came from the American Medical Museum (AMM) and the sample was biased towards cranial remains with little post-cranial representation. Many of the skeletal remains curated at the AMM were recovered by US Army field surgeons who were encouraged to collect human remains under policies outlined by the Surgeon General's Office (Makseyn-Kelley 1999). In 1862, the Surgeon General issued a request for skeletal remains with projectile trauma (Makseyn-Kelley 1999). Therefore, the high frequency of trauma observed in the Sioux sample is likely not representative of the tribe, but rather a reflection of the collector bias.

Excavator biases were recognized and addressed in this research. Future analyses may benefit from more in-depth analyses of the biases associated with large-scale digitized datasets and archival data. How do these biases affect our interpretations of the past? Are biases minimized by the large volume of archival data?

Inadequate Sample Sizes

In the present research, each of the ten sites included in the sample was analyzed independently, but the trauma frequencies were reported in aggregate. The RBS Program, conducting salvage archaeology, did not always collect skeletal remains in a systematic manner and not every site included in the study yielded an accurate sample of the site’s population. For this reason, it was hypothesized that the frequency of trauma observed at sites yielding small sample sizes may misrepresent that place and time. Because of the sample size in many of the sites used in this research, trauma frequencies were presented as aggregate data combining the sites together and then dividing the sample temporally and regionally. One example of a site with a small sample size and a high frequency of trauma is the Leavenworth Site. The trauma frequency at Leavenworth was 23.3%, the second highest trauma frequency observed in any of the sites in the sample. However, when compared to a larger, more representative sample excavated from the Leavenworth site in the 1960s, the frequency of trauma recorded in this research appears to misrepresent the place and time.

Stewart Shermis (1969) reported on the skeletal pathology at the Leavenworth Site in a master’s thesis. Shermis' skeletal sample consisted of remains excavated during the summers of 1965 and 1966 from the Leavenworth Site Cemetery (Shermis 1969:3). Excavations were directed by Dr. William M. Bass, and after burials were located, each burial was carefully excavated by hand. At the time of analysis, it was estimated that over 90% of the cemetery population was recovered (Shermis 1969:3). A later assessment by Bass et al. (1971) suggest that this estimated rate of recovery is unlikely and it is probable that the cemetery was only used by a segment of one of the villages and is therefore not representative of the whole population (161). In total, the cemetery sample consisted of 285 skeletons. Demographically, the sample was subdivided by age and sex (Tables 13 and 14).

Table 13. Age Distribution of the 1965 and 1966 Leavenworth Cemetery Excavations (Table 1; Shermis 1969:8)

Age Group	Total	Percent of Total
Birth – 2 yrs.	97	30.4%
2-5 yrs.	36	12.6%
6-11 yrs.	20	7.0%
12-14 yrs.	11	3.9%
18-30 yrs.	52	18.2%
31-40 yrs.	24	8.4%
40+	15	5.3%
Indeterminate	30	10.5%
Total	285	100.0%

Table 14. Sex Distribution of the 1965 and 1966 Leavenworth Cemetery Excavations (Table 4; Shermis 1969:9)

Age Group	Total	Percent of Total
Male Adult	52	18.2%
Female Adult	50	17.5%
Indeterminate Sex, Adult	13	4.6%
Indeterminate Sex, Subadult	170	59.6%
Total	285	100.0%

As one portion of his work, Shermis (1969) studied trauma of the Leavenworth Cemetery sample, looking specifically at fractures, projectile injuries, and traumatic myositis ossificans. Of interest to the present research was the frequency of fractures among the Leavenworth Site skeletons. In total, Shermis reported that 4.6% (13/285) of the Leavenworth Cemetery sample showed evidence of fractures (1969:21). Of the 13 individuals with trauma, four were female, seven male and two were of an indeterminate sex. One of the females had fractures to the ribs reported to result from osteomyelitis (Shermis 1969:48). If this individual is excluded from the trauma frequencies (the fractures were infection-induced, rather than traumatic in nature), the frequency of trauma is reduced to 4.2%. The results of his trauma analysis indicated no significant difference in the incidence of fractures between the sexes; however, the locations and types of fractures suggested a culturally-derived pattern of injury (Shermis 1969:11). Fractures sustained by females were mostly of a “defensive nature” (Shermis 1969:14). “Fracture lesions of the rib, arm, and face as well as a broken tail-bone seem to suggest physical beatings in that they duplicate known defense fractures” (Shermis 1969:14). The majority of fractures sustained by males were attributed to warfare or war-like games (Shermis 1969:20).

The high frequency of trauma observed in the Leavenworth sample curated at the SI may result from the U.S. Army and Sioux attack in 1823. The SI sample was excavated from both the village and associated cemeteries and therefore may represent the remains of individuals associated with the Euroamerican-Sioux attack on the village. Comparisons drawn with Shermis' analysis of the Leavenworth Site demonstrate the potential biases associated with using small sample sizes. As has been shown, the trauma frequency (23.3%) reported for the Leavenworth Site in the present research does not appear to be an accurate reflection of the site as a whole. The sample utilized by Shermis consisted of 285 skeletons excavated by Bass and is likely to be a more accurate representation of the cemetery population. The trauma frequency of Shermis' sample was 4.2%, suggesting that the heightened frequency of trauma recorded from the SI materials may over-estimate trauma due to small sample size and inadequate site representation at the Leavenworth Site. This finding provides empirical support and justification for the use of aggregate data in the remainder of the analysis of skeletal trauma in the SI Arikara sample.

ARIKARA TRAUMA ANALYSIS

A lack of integration between the osteological data and archaeological and provenience data prevented a thorough bioarchaeological interpretation of the human skeletal remains analyzed by the SI. Because the qualitative observations of the skeletal remains could not be contextualized in a mortuary context, the analysis of trauma was heavily reliant on taking a population-based assessment of trauma patterns within the Arikara sample.

Sex and Age Differences

When assessing the frequency of skeletal trauma in the Arikara tribe, the results of the statistical analysis support the third hypothesis. Males exhibited a higher than expected frequency of skeletal trauma than females. As outlined in the second chapter, trauma has many definitions and traumatic injuries to the human skeleton can be acquired both accidentally and intentionally. The total frequency of skeletal trauma in the first set of analyses include both accidental and intentional injuries. Consequently, the injuries reflect participation in acts of aggression, such as warfare, and involvement in daily activities. Differentiating between intentional and accidental trauma can best be addressed through a consideration of wound patterning (Schulting and Fibiger 2012). Patterned injuries reflect the repetitive placement or position of injuries and in conjunction with other evidence, such as an individual's age or sex, may be identified with a particular event or activity (Schulting and Fibinger 2012). In the present study, wound patterning was addressed by body region affected. The skeleton was divided into five regions: (1) splanchnocranium with the addition of the frontal, (2) cranial vault, (3) axial skeleton, (4) upper appendicular skeleton, and (5) lower appendicular skeleton.

The most commonly affected region in both sexes was the facial skeleton combined with the frontal. The second-most common injury observed in females were injuries to the cranial vault, followed by the upper appendage, the axial skeleton, and finally the lower appendage. Following facial trauma, males were next most likely to exhibit trauma to the lower appendages, followed by upper appendages, axial skeleton and finally the cranial vault. When comparing the pattern of injuries between the sexes, females had a higher frequency of cranial vault trauma than expected, while males had a higher frequency of trauma to the lower appendage than expected.

There are a number of explanations for the difference in wound patterning when comparing sexes. First, the higher than expected frequency of cranial vault trauma in females may be attributed to a number of different activities, including active involvement in warfare (i.e., direct participation in hand-to-hand combat), peripheral involvement in war (i.e., village raids), and domestic disputes. The first two explanations will be discussed further in the next section pertaining to interpersonal violence, so this discussion will focus on the skeletal indications of domestic abuse. A recent article by Redfern (2015) discusses the clinical and social science datasets used to identify domestic violence victims in the archaeological record. Traditionally, paleopathological and bioarchaeological interpretations of the skeletal manifestations of domestic abuse have focused on wound patterns in the victim. In the archaeological record, victims of domestic violence have been reported to sustain a higher frequency of injuries to the face, head and neck (Redfern 2015). This pattern of injury was adopted from clinical approaches to domestic violence and many past studies failed to recognize that trauma is always temporally and geographically specific and should be interpreted as such (Redfern 2015). Trauma should always be defined within a culturally-specific framework. Redfern (2015) asserts "it is imperative that domestic violence is not studied in isolation from a community's notion of gender, life course and evidence of other types of violence (child abuse or warfare), and above all, we should recognise that it is often impossible to isolate the different threads that create a 'web of violence' and its traces, which are incorporated into the bodies of past people."

In modern clinical and forensic settings, injuries resulting from domestic violence are often sustained to the face, head, neck, arm and are most frequently observed in young and middle aged adults (Novak 2006; Allen et al. 2007; Juarez and Hughes 2014; Redfern 2015). However, so much overlap in the pattern of injuries sustained from domestic abuse, assaults, and accidents occurs that recently bioarchaeologists caution against interpreting injury patterns because no definitive fracture or fracture pattern is diagnostic of domestic abuse (Juarez and Hughes 2014:361). Taking these cautionary notes into consideration, the increased frequency of cranial vault trauma and high levels of facial trauma observed in the female Arikara sample may be interpreted as resulting from domestic disputes. When interpreting the pattern of injury in the "web of violence" as outlined by Redfern (2015), elevated levels of domestic aggression would be likely considering the external influences. During the Extended Coalescent and Post-Contact Coalescent variants, the Arikara experienced increased pressures from Euro-American expansion into the Plains. The Arikara, acting as middlemen in a vast trade-network, were often in conflict with both European traders and neighboring Native American tribes (Owsley 1994). Previous studies of violence reported increased frequencies of domestic injuries during or after war, as well as in times of economic hardship (Colson 1995; Saile et al. 2013; Redfern 2015). The traumatic injuries observed in the Arikara sample may reflect a tumultuous time when the Arikara experienced increasingly frequent interactions with Euro-Americans, a reduction in population size from epidemic diseases, and increased contact with neighboring tribes. All of these factors may have contributed to economic hardship and social unrest in the Middle Missouri River Valley and ultimately could have led to an increase in domestic disputes within the villages.

In addition to a consideration of external influences on a society, such as warfare, domestic violence must be understood as the effect of gender inequalities in the community (Redfern 2015). Early historic and ethnographic literature report that women were viewed as beasts of burden, and served the function of laborer within Arikara society (Holliman 2000:27). However, more recently, it has been suggested that European and American accounts of early historic period Arikara societies represent biased views of women (Sundstrom 2015). Arikara societies were matrifocal, and the importance of women in these societies is evident in every major aspect of village life, including hunting, warfare, and religion (Peters 1981: 158; Sundstrom 2015). While social prestige and economic status depended on the reputation of the husband as a warrior, men and women in early Arikara society understood that the husband only ascended in socioeconomic status if the wife did her part (Peters 1981:86). Authors have suggested that the misrepresentation in early European and American accounts of Arikara women were based on preconceived notions of leadership and a misunderstanding of Native American culture (Peters 1981:63). Therefore, it is unlikely that women were subjected to high levels of domestic abuse within Arikara society. A final reference to the interpersonal relationships within Native American tribes is presented by Hamby (2005) who states,

> "Much of the literature is heavily politicized. Early literature on Native communities has been criticized for overly negative and skimpy portrayals of women that were often excessively colored by colonial and missionary attitudes. In recent years, however, the political pendulum has swung in the opposite direction and American Indians are often idealistically held up as examples of egalitarian or matriarchal societies (i.e., Guemple 1995). The implications of these portrayals is that violence was not part of male-female relations in matriarchal societies. Neither portrayal is accurate" (180-1).

This sage advice from Hamby reminds us to temper our interpretations of past peoples and their interpersonal relationships.

The higher-than-expected frequency of lower appendicular injuries among males are unlikely to result from interpersonal aggression and are more likely the result of accidental injuries. In Arikara society, male roles included hunting and participation in warfare. These activities in the late protohistoric and early historic period would likely have involved horses after they were integrated into Middle Missouri tribes in the mid-18th century (McGinnis 1990). A modern study of equestrian injuries concluded that the most common injuries while mounted on a horse occurred after being thrown or falling from the animals back (Thomas et al. 2006:619). Injuries that occurred while not mounted were most frequently acquired through a kick from the horse and injuries were most frequently sustained to the head/neck region (23.2%) and the lower extremity (22.2%) (Thomas et al. 2006:619). A number of male injuries to the lower appendage and facial bones may be attributable to their increased interaction with horses, or other large, hunted prey. An alternative explanation for the high frequency of male facial trauma is male subjection to domestic abuse. Because of the marked overlap in the pattern of injury observed in assault victims and victims of domestic abuse, male victims of domestic abuse often go unrecognized because their injury patterns are erroneously interpreted as evidence of assault in battle.

Finally, the results contradict the third hypothesis which predicted that members of the Young Adult age group would have the highest frequency of trauma. In the Arikara sample, the frequency of traumatic injuries increased with age, regardless of sex. Both the Middle Adult and Old Adult age categories showed higher than expected frequencies of trauma. The heightened frequency of trauma with increasing age can be attributed primarily to the cumulative nature of injuries over the course of a lifetime (Glencross 2011). Due to the nature of the sample, which contained very few perimortem injuries (n=12), it is difficult to tell the age of the individual when the skeletal trauma occurred. So, it is quite possible that injuries sustained when an individual was young remained visible on the skeleton for the rest of the person's life. As an example of cumulative injuries, in the sample there were 20 cases of injury recidivism, or repeated injuries in a single individual (Judd 2002). Ten cases of multiple injuries were males and ten cases females, suggesting that members of both sexes were involved in a repetitive aggressive behavior that resulted in injury, although injuries could have been sustained under very different circumstances. Interestingly, one of the individuals with the greatest number of skeletal trauma was a middle aged, adult male (30-49 years) with four injuries: perimortem blows to the left and right parietals, with subsequent modification for potential use as a trophy skull, antemortem blow to the right eye orbital, healed depressed cranial fracture to the left parietal, and a perimortem fracture to the left mandibular ramus. Those injuries occurred at different times indicating that this individual was involved in aggressive acts on at least two occasions. This case supports the idea that the increase in the frequency of injuries in Old Adults results from the cumulative nature of injuries throughout an individual's lifetime.

Temporal and Regional Patterns

The results of the study contradict the fourth hypothesis. The temporal analysis revealed different levels of trauma in the Pre-Contact and Post-Contact periods with significantly higher frequencies of skeletal trauma observed in the Pre-Contact period. When considering the sexes separately, no significant difference in trauma frequency was observed in males when comparing the time periods, however, females had a significantly higher frequency of trauma in the Pre-Contact period. With regards to geographic distribution, there was not a statistically significant difference in the frequency of trauma between the Grand-Moreau and the Bad-Cheyenne regions. What these results suggest is the persistent nature of warfare and aggression from the Pre-Contact to the Post-Contact period. In the Pre-Contact period, instead of direct involvement in hand-to-hand combat either between tribes or between Native Americans and Euro-Americans, warfare may have focused more on less lethal forms of aggression such as village raids which included the indirect involvement of females. Intertribal warfare will be discussed further in the next section.

INTERPERSONAL VIOLENCE ON THE PLAINS

To test the fifth hypothesis, this study assessed the social interactions of the Arikara through three skeletal markers indicative of interpersonal violence: craniofacial and cranial vault injuries, projectile or bladed weapons trauma, and evidence of mutilation. No significant differences occurred in the skeletal markers comparing the sexes, different age groups, temporal periods, or regional variants. While no tests proved to be statistically significant there were meaningful differences, which will be discussed.

Sex and Age Differences

The analysis of markers of interpersonal violence between the sexes showed that males had higher frequencies of craniofacial trauma and projectile point trauma, while females had higher frequencies of cranial vault trauma and scalping. There were also differences when comparing the indicators of interpersonal violence among the age groups. Craniofacial and cranial vault injuries were most frequently observed in Old Adults, projectile injuries occurred most frequently in Young Adults, and evidence of trophy taking was observed most frequently in Adolescents. While there were few Children with skeletal markers of interpersonal violence (n=2), there were nine Adolescents with probable violent injuries. In most cases of injury in Adolescents, the injuries were sustained in individuals over the age of 17 and the pattern of injury closely mirrored the injury patterns observed in adults; males manifesting projectile and craniofacial injuries and females exhibiting injuries to the cranial vault. Two of the three individuals with scalping cut marks were Adolescent females. These finding suggest that Adolescents were involved in the same activities and potentially violent encounters as their adult counterparts.

The majority of injuries in the Arikara sample were antemortem injuries. The age distribution of markers of interpersonal violence, therefore, may not be reliable because injuries are cumulative during an individual's lifespan (Glencross 2011). Perimortem injuries will be discussed for the remainder of this section because there is no definitive way to determine when an injury occurred in the antemortem interval. In this study, only 12 individuals had perimortem injuries: six males, four females, one adolescent and one child. Three of the four females with perimortem injuries exhibited depressed cranial fractures, two Young Adults and one Middle Adult. The fourth female with perimortem trauma was an Adolescent exhibiting scalping cut marks on the cranial vault. Five of the six males with perimortem trauma exhibited skeletal manifestations of weapon-related violence, including a musket ball injury to the ilium of a Young Adult, blunt force cranial trauma and evidence of potential trophy taking (drill holes) on a Middle Adult, sharp force trauma to the cranium of a Middle Adult, and two cases of sharp force trauma to the axial skeletons of a Young Adult and Middle Adult. There was only one case of a perimortem injury that did not represent interpersonal violence, a Middle Adult male with perimortem vertebral compression fractures in thoracic vertebrae 11 and 12.

The increased incidence of lethal injuries in Young and Middle Adults suggested a pattern of injury correlated with participation (both direct and indirect) in violent acts such as warfare, raiding, or village defense. The patterns of injury, females with depressed cranial fractures and trophy taking, and males exhibiting weapon-related injuries, suggested a differential risk of injury based on sex and age. The data suggest that involvement in war or aggressive behavior was determined largely by an individual's age and sex. Young Adult males were more engaged in forms of warfare than other demographic groups. Alternatively, the pattern of injury observed in young females suggested more passive involvement in war, likely the result of victimization during village raids.

Most historic descriptions of Arikara women depict them as passive victims of warfare. Early travelers and traders reported that women were vulnerable while working in the fields near the village. This raiding included shooting and scalping of female victims (Taylor 1897). Arikara women are thought to have been susceptible to violence inflicted by the Sioux, a neighboring nomadic tribe competing for land and trade system resources. A probable scalping at the Sully Site is cited as supporting evidence of violence against women during village raids and other documentary sources suggest that the Sioux were known to beat or kill Arikara women during horse stealing raids (Abel 1939). Tribal relations in the early historic period were volatile, and even on the day directly following a friendly exchange of goods, warriors of the nomadic tribes returned to raid for horses or other goods from the more sedentary village tribes, such as the Arikara (McGinnis 1990). Compared to their nomadic neighbors, village tribes were often small in number and vulnerable because of their immobility. Early historic accounts of intertribal relations could not comprehend this type of combat, as European rules of warfare did not permit killing civilians and discouraged the slaughter of women and children (McGinnis 1990:4). These ethnocentric views lent themselves to claims of savagery by Native Americans. Unlike European war tactics, intertribal warfare often focused on individual bravery and spiritual power than the outcome of a battle (McGinnis 1990). Tribal victories occurred through the defense of a village or the discovery that an opponent was weak (i.e., could not defend their women and children; McGinnis 1990:4). It is possible that the perimortem injuries observed in the Arikara female sample resulted from the Arikara falling victim to non-lethal village raids by neighboring Native American tribes.

Unlike the female victims, males with skeletal markers of interpersonal violence mostly exhibited injuries related to weaponry. Many of the perimortem injuries sustained by male victims, such as sharp force trauma to the axial and cranial skeleton and a potential trophy skull, suggested hand-to-hand combat and direct involvement in warfare. Likewise, the musket ball injury is not likely to have occurred within the village. As mentioned previously, male victims of domestic violence are often misidentified as victims of assault due to the high amount of overlap in wound patterning (Redfern 2015). Therefore, it is also possible that some of the perimortem injuries documented in male skeletal remains may have resulted from aggressive interactions within the village or between intimate partners.

Temporal and Regional Patterns

The frequency of all skeletal markers of interpersonal violence remained stable through time. None of the statistical analyses yielded significant results, but there were slight increases in the frequency of craniofacial and weapon-related trauma in the Post-Contact period. When all indicators of interpersonal violence were combined, no significant difference between the temporal periods occurred. One of the reasons for the increase in craniofacial and weapon-related trauma may be the changing pattern of warfare from the protohistoric through the historic period.

One of the earliest historical records of explorers in the Southern Plains comes from Francisco Vasquez de Coronado. Coronado was followed by Spanish military expeditions in the 1600s and 1700s (McGinnis 1990: ix). While French traders traversed the Southern Plains in the 1700s, the northern high plains remained relatively unknown to Euro-Americans until the late 1700s and 1800s when trading and exploratory expeditions began. Early European accounts reported the Indians engaged in constant warfare (McGinnis 1990: ix). Continuous tribal migration and the acquisition of horses and firearms compounded intertribal hostilities in the Post-Contact period. However, when compared to modern warfare practices, Native conflict was limited and hostilities were often set aside in order to establish a truce between nomadic and sedentary tribes who needed the goods the other supplied (McGinnis 1990: x). Also, many tribes depended on male participation in hunting and recognized that they could not afford the high casualties associated with direct warfare.

From the earliest contact, Europeans and Americans became involved in intertribal relationships, influencing and altering tribal interactions with firearms, trade goods, and newly established Euroamerican-Native alliances (McGinnis 1990: x). The two biggest contributing factors altering Native relationships and lifeways were guns and horses. They provided tribes with more lethal forms of weaponry and increased mobility, forever changing the Pre-Contact modes of warfare. In the early 1700s, horses reached the Plains, coming from Spain by way of the tribes west of the Rocky Mountains (McGinnis 1990:6). Firearms arrived, and after the 1730s, guns and horses initiated gradual changes on the intertribal conflicts in the Northern Plains (McGinnis 1990:9).

As contact with Euro-American trader increased, so did the frequency and intensity of intertribal conflict. By the 1780s and 1790s, Euro-American contact altered intertribal relations to the point that a major shift in the balance of power occurred, which is said to have produced major changes in Plains culture and warfare practices (McGinnis 1990: 10). A number of factors contributed to this shift in the balance of power among Plains tribes, including: (1) increased mobility raised the level of competition for hunting grounds, (2) growing White American and English settlement in the East initiated a chain of Indian migrations that reached the Plains tribes (3) increased access to European goods altered Plains culture in terms of transportation, hunting, and war, and (4) the fur trade brought new diseases which had a devastating impact on Native American population size. In addition to smallpox, cholera and other diseases killed more Native Americans than guns or war (McGinnis 1990:10). The high frequency of trauma at the Leavenworth Site likely reflects this transition in warfare tactics. Each of the seven individuals with skeletal trauma at Leavenworth displayed at least one skeletal marker of interpersonal violence, suggesting a heightened incidence of violent interaction in the historic period than in the pre-historic and proto-historic periods. While the trauma observed at the Leavenworth Site may reflect a single attack upon the village by the U.S. Army and the Sioux in 1823, this aggressive interaction marks a period of instability and hostility between Native American tribes and Euro-Americans.

This discussion outlines the ever-changing nature of intertribal relations from the protohistoric through the historic period. Intertribal warfare and raids were a well-established practice in the Plains long before European contact. Contact and access to European trade goods changed the form of warfare, however, it did not necessarily alter the frequency of warfare until later in the historic period, a date succeeding the sample used in this research. While the Post-

Contact Coalescent variant extends into the 1880s, the sample used in this study only dates as late as 1832.

The comparable frequency of skeletal markers suggesting interpersonal violence in the Extended Coalescent and Post-Contact Coalescent variants, may be a reflection of the enduring nature of aggressive intertribal interactions. The increase in craniofacial and weapon-related trauma in the Post-Contact groups likely reflected the increased availability of European weapons and shift from warfare to intertribal raiding with young men engaging in individual combat. The patterns of injury suggest that intertribal raiding was the most common method of warfare practiced in both the Pre-Contact and Post-Contact periods (Owsley 1994). Instead of contact with Euro-Americans increasing the frequency of intertribal raiding, there appears to be a continuance of long-standing violent engagements from the protohistoric to historic period. A general lack of evidence of high mortality in Young Adult males and the low frequency of perimortem trauma are also consistent with small-scale raiding as the primary form of aggressive intertribal interactions in the region (Owsley 1994).

There is no evidence to support regional differences in the Arikara sample. The frequency of cranial, projectile, and mutilation injuries were roughly equivalent in the Bad-Cheyenne and Grand-Moreau regions. The lack of regional differences may be explained by the fact that the ten sites used in this research were in close proximity, geographically. Therefore, each of the ten sites was likely subject to the same external pressures, resulting in comparable injury patterns in those two regions of the Middle Missouri River Valley.

SIOUX COMPARATIVE SAMPLE

Regarding the sixth hypothesis, the SI RDBMS is amenable to altering the scale of an analysis. To draw comparisons with the Arikara sample, a sample of Sioux data were exported from the SI relational database. As stated in the results section, only crania were assessed because the Sioux skeletal remains had few associated post-cranial elements. The Sioux sample consisted of 77 crania dating to the Post-Contact period. When comparing skeletal markers of interpersonal violence between the two tribes, Sioux craniofacial trauma was documented in twice as many males as females (16.2% and 8%, respectively). In the Arikara sample, the frequency of craniofacial trauma was almost equal between males and females (12.8% and 10.8%, respectively). Differences occurred between the two tribes when comparing the frequency of cranial vault injuries. In the Sioux sample, cranial vault injuries were only observed in males. Interestingly, in the Arikara sample the frequency of cranial vault injuries was doubled in females when compared to males (6.3% and 3.1%, respectively).

The sample used in the comparative study included skeletal remains that have been culturally affiliated to the Oglala and Brule Sioux tribes. During the 17th century, the Oglala and Brule Sioux acquired firearms from Euro-Americans through direct contact. In the mid-18th century, the Oglala and the Brule encountered the Arikara in the Great Bend Region of the Middle Missouri River Valley (Makseyn-Kelley 1999:9). At this time the Arikara were relatively wealthy from their participation in trade with Euro-Americans. The Oglala and Brule encroached on Arikara territory in the mid-18th century, when they crossed the Missouri River. The tribes remained on relatively friendly terms for a period of time, but eventually the Oglala and Brule, having increased their population size and domination of the region, came together to oust the Arikara from their habitation of the Great Bend region (Makseyn-Kelley 1999:10). The tension between the Arikara and Sioux was documented by a number of historic references and the Sioux were reported to have kept the Arikara terrorized in the late Post-Contact period (Meyer 1977). The Sioux claimed "that the Arikara took the place of women in their economy" (Meyer 1977:39-40). The Sioux were said to set their own prices and take whatever they desired. Even while exchanging goods on relatively friendly terms, the Sioux were reported to pillage Arikara fields, steal their horses, and beat Arikara women. Once trading was complete, the Sioux sometimes remained close to the village to keep the bison away, so that they could then sell meat and hides to the Arikara, who were forced to trade their bows and arrows from their tormentors (Meyer 1977:39-40). Arikara women were vulnerable to the violence inflicted by the Sioux. Traveler memoirs described Arikara women as victims of warfare and several reported women falling victim during raids while they were working in the fields. Historic sources reported that the Sioux beat or killed Arikara women during horse stealing raids (Abel 1939).

Sioux Summary

What the differences in cranial trauma may imply are different patterns of involvement in warfare practices between the Sioux and the Arikara. The sex differences in the frequency of cranial trauma may be a result of different roles played in intertribal warfare, with males (both Arikara and Sioux) participating in direct combat while Arikara females were subjected to village raids. The data suggest that the high incidence of cranial vault trauma in the Arikara female sample reflect their passive involvement in warfare activities, such as raids. The Sioux, less likely victims of village raids, do not have a high frequency of warfare-related trauma in the female sample.

CHAPTER 10: SUMMARY & CONCLUSIONS

The results of this research suggest that the ROL has developed a highly effective and accessible database of osteological data, and a consistent method of recording for human skeletal remains. The osteological data can be quickly and easily isolated, exported, manipulated and analyzed. The one shortcoming of the osteological data is a lack of standardization in the photographic and radiographic images. In the future, standards should be developed for all photographic and radiographic images and these materials should be curated with the osteological data or in an associated database. Likewise, the nature of the osteological database makes it clear that similar standards need to be created for the archaeological data. While the SI repatriation data were useable for original research, the lack of association between the osteological data and archaeological and contextual burial data hindered bioarchaeological research. While archaeological and mortuary data were not always available, the archaeological data that were collected and burial provenience (when known) should be standardized and linked to the osteological database. Integrating archaeological and contextual information would serve to strengthen interpretations of the skeletal remains and enhance a bioarchaeological approach to studying past people.

While there were minor complications in accessing the SI osteological data, and a lack of integration of the osteological data with provenience and artifact data, the efforts undertaken by the SI go unparalleled and the Institution has demonstrated the importance of preserving our skeletal record of the past. With the development of *Standards* and the creation of Osteoware, the SI has preserved and made available large-scale databases to be used by future researchers of repatriated collections that are no longer accessible. Not only has digitization of osteological data led to long-term preservation of the bioarchaeological record, the creation of large-scale databases has changed the way we conduct bioarchaeological research. Digitized osteological databases present opportunities to conduct macro-regional and –temporal analyses. By increasing the temporal and geographic range of our samples, we have increased the breadth of our understanding of the deep human past. Bioarchaeologists can use large-scale databases to document changes through time and space, as well as interpersonal interactions between, and not only within, a single population. The remainder of this chapter will discuss the value of this research for understanding violence on the North American Great Plains and avenues for future research.

INTERPERSONAL VIOLENCE ON THE PLAINS

As demonstrated by this research, violence in the Arikara tribe was a long-standing cultural tradition that pre-dated European contact. While injuries tended to accumulate with age in both sexes, there was a different pattern of injury for males compared to females. The injury patterns suggest that intertribal raiding was the most common method of warfare practiced in both the Pre-Contact and Post-Contact periods. Instead of contact with Euro-Americans increasing the frequency of intertribal raiding, long-standing violent engagements from the proto-historic through the early historic period continued. A general lack of evidence of high mortality in Young Adult males (when compared to other sex and age groups) and the low frequency of perimortem trauma were also consistent with small-scale raiding as the primary form of aggressive intertribal interactions in Middle Missouri River Basin.

A comparison of injury patterns with a sample of Sioux corroborated the proposed hypothesis of continuing violent interactions by inter-tribal raiding. The differences in cranial trauma between the Arikara and Sioux samples suggested different patterns of involvement in warfare practices. This research suggested that a high incidence of cranial vault trauma in the Arikara female sample may reflect passive involvement in warfare activities, such as raids. When compared to the nomadic Sioux tribe, the pattern of increased cranial vault injuries in Arikara females was not observed in the Sioux female sample. The difference in wound patterning between village and equestrian groups was supported by the ethnographic and historic reports of victimization of the Arikara by their equestrian neighbors (Meyer 1977).

FUTURE CONSIDERATIONS

There are a number of avenues for future research that would strengthen interpretations of the archaeological record using digitized data. First, as mentioned throughout this dissertation, the SI Arikara sample was incomplete, attributable to both excavator biases and also to the splitting of village samples between institutions. Future efforts to integrate digitized collections between institutions would allow a more complete assessment of past populations. In this research, it was not possible to perform a demographic analysis due to the biases associated with the SI collection. In addition to excavator bias, such as those associated with Stirling, years later biases also arose with the RBS. Many archaeologists were employed by the RBS and each archaeologist had sampling biases. Many archaeologists were also working on behalf of different institutions and the archaeological collections were subsequently divided between institutions. Demography is an important component of a trauma analysis and a method of analysis that could not be assessed in the present research. According to Redfern (2015), "the importance of demographic trends to understanding how trauma relates to other health conditions is emerging with mortality modelling redefining the injury recidivist model proposed by Judd (2002)".

Mortality modelling suggests that people with multiple injuries have higher mortality rates than their non-multiply injured peers. In the future, to decrease sampling bias and increase sample size from each Arikara site, skeletal collections from different institutions need to be integrated into a single dataset. The collection of osteological data according to *Standards* will facilitate this process, however, many issues exist with making skeletal collections available to researchers outside of an institution. The archaeological and bioarchaeological communities are beginning to open the dialogue regarding open access to collections and rights of ownership for osteological data (Kintigh 2006). However, as a field we are still in the very beginning of this important discussion.

Second, the osteological data used in the present study should be correlated with data pertaining to health to assess different treatment between the sexes. Applying a resource-stress model, violent human interactions are viewed as a strategy employed to improve a group's chance of survival and successful reproduction from the forceful acquisition, reallocation, and defense of food resources (Ferguson 1990; Gross 1975; Harris 1984). Skeletal evidence of poor health, including cribra orbitalia and porotic hyperostosis, have been used to explain violent human interactions as stemming from inadequate resource availability. Preferential access to resources may indicate different treatment in a population on the basis of an individual's age or sex. An investigation of skeletal markers of health could yield information pertaining to gender roles in Arikara society, such as gender- or age-biased access to resources. Such differential treatment may be correlated with gender differences observed in warfare practices.

Finally, future research needs to assess inter-observer error rates when using previously recorded data. With the current research, it was difficult to assess inter-observer error for three reasons: the skeletal materials were no longer accessible, photographs and radiographs were not always available, and a number of individuals performed data collection on a single skeleton. Because more than one person recorded data from each skeleton (i.e., one individual recorded age and sex, while a second individual recorded trauma), it was impossible to determine if one osteologist recorded unusually high levels of trauma compared to other data recorders. Also, not all data recorders in the ROL had the same level of osteological experience. Each of these factors contributed to the relatively imprecise assessment of inter-observer error in the present research. Future research should assess the effect of inter-observer error when working with digitized archival data and how this potential bias affects our interpretations of past populations.

APPENDICES

APPENDIX A

Osteoware Codes

Pathology Module
1. Abnormal Shape
2. Abnormal Size
3. Bone Loss
4. Abnormal Bone Formation
5. Fractures and Dislocations
6. Porotic Hyperostosis
7. Vertebral Pathology
8. Arthritis

Aspect
1. Superior Surface/Outer Table
2. Inferior Surface/Inner Table
3. Medial
4. Lateral
5. Dorsal
6. Ventral
7. Circumferential

Side
1. Right
2. Left
3. Both sides
4. Midline
5. Unknown

Section
1. Proximal Epiphysis
2. Proximal 1/3 of Diaphysis
3. Middle 1/3 of Diaphysis
4. Distal 1/3 of Diaphysis
5. Distal Epiphysis

Skeletal Elements
100. Total Skeleton
200. Skull
201. Frontal
202. Parietal
203. Occipital
204. Temporal
205. Zygomatic
206. Maxilla
207. Mandible
208. Palatine

Cranial Bones
218. Hyoid
219. Nasal
220. Sphenoid
221. Frontal & Left Parietal
222. Frontal & Right Parietal
223. Frontal & Both Parietals
224. Occipital & Right Parietal
225. Occipital & Left Parietal
226. Occipital & Both Parietals
227. Frontal, Occipital & Parietals
228. Temporal Fossa

Axial Skeleton
300. Axial Skeleton
301. Vertebral Column
310. Cervical Vertebrae
311. C1
312. C2
313. C3 – C6
314. C7
320. Thoracic Vertebrae
321. T1 – T9
322. T10
323. T11
324. T12
340. Lumbar Vertebrae
341. L1
342. L2
343. L3
344. L4
345. L5
350. Sacrum
360. Coccyx
370. Ribs
371. 1st Rib
372. 2nd Rib
373. Ribs 3-10

* The Skeletal Pathology Codes in Osteoware are based upon the Chicago system which emphasizes a descriptive approach in the documentation of skeletal pathology.

Axial Skeletal Continued
374. Rib 11
375. Rib 12
390. Sternum
391. Manubrium
392. Sternal Body
393. Xiphoid Process

Appendicular Skeleton
400. Appendicular skeleton
401. Scapula
402. Glenoid Fossa
403. Clavicle
404. Ox Coxae
405. Ilium
406. Ischium
407. Pubis
408. Acetabulum
410. Upper Limb
411. Humerus
412. Radius
413. Ulna

Hand
420. Carpals
421. Scaphoid
422. Lunate
423. Triquetral
424. Pisiform
425. Trapezium
426. Trapezoid
427. Capitate
428. Hamate
430. Metacarpals
431. MC1
432. MC2
433. MC3
434. MC4
435. MC5
440. Hand Phalanges
441. Proximal Row Hand Phalanx
442. Middle Row Hand Phalanx
444. Phalanx, 1st Proximal Hand
445. Phalanx, 1st Distal Hand

Lower Limb
501. Femur
502. Patella
503. Tibia
504. Fibula
510. Tarsals
511. Talus
512. Calcaneus
513. Cuboid
514. Navicular
515. Medial Cuneiform
520. Metatarsals
521. MT1
522. MT2
523. MT3
524. MT4
525. MT5
530. Foot Phalanges
531. Proximal Row Foot Phalanx
532. Middle Row Foot Phalanx
533. Distal Row Foot Phalanx
534. Phalanx, 1st Proximal Foot
535. Phalanx, 1st Distal Foot

Pathology Code 5: Fractures & Dislocations

Observation 1 (OBS1): Completeness
11. Complete (broken into two or more pieces)
12. Partial (not broken into separate pieces)

Observation 2 (OBS2): Type
21. Partial (Greenstick/Bowed)
22. Simple (Transverse/Oblique)
23. Comminuted/Butterfly
24. Spiral
25. Compression/Torus
26. Depressed Skull Fracture, Outer Table only
27. Depressed Skull Fracture, Outer and Inner Table
29. Other

Observation 3 (OBS3): Fracture Characteristics
28. Pathological
31. Blunt/Round
32. Blunt/Oval
33. Edged/Sharp Force Trauma
34. Projectile Entry
35. Projectile Exit
36. Projectile Embedded
37. Radiating/Stellate
38. Amputation
39. Other

Observation 5 (OBS5): Perimortem Fractures
51. Clearly Perimortem
52. Ambiguous; Possibly Perimortem

Observation 6 (OBS6): Antemortem Fractures/Healing
61. Callus Formation, Woven Bone Only
62. Callus Formation, Sclerotic Reaction
63. Healing, Obliteration of Fracture

Observation 7 (OBS7): Fracture Complications
71. Nonunion
72. Tissue Necrosis
73. Infection
74. Traumatic Arthritis
75. Joint Fusion
76. Traumatic Myositis Ossificans
77. Deformation
78. Traumatic Enthesopathy

Observation 9 (OBS9): Dislocation
91. Traumatic
92. Congenital
93. Cause Ambiguous

**Observations 4 and 8 are available when the recorder finds it necessary to record two observations for a particular trait. OBS4 and OBS8 are useful in cases of complex injury, e.g. a case of (1) blunt/round cranial trauma with (2) radiating fracture lines.

APPENDIX B

SI RDBMS Table Variables

Advantage™ Table Variables

AGESEX Table:

Catkey*
Indiv
Trackno
RECR
EntryDate
METOSUTU
MENTSYMP
LATBASIL
LATSQUAM
BASILSUT
CHARLARCH
CHARCHCEN
CSUPERIM
CINFERIM
THALARCH
TARCHCEN
TSUPERIM
TINFERIM
LARCHCEN
LSUPERIM
LINTERIM
SCAPCORA
SCAPGLEN
SCAPACRO
SCAPINFA
SCAPMBOR
CLAVSTER
PROXIHUM
DISTAHUM
HUMEPICO
DISTARAD
PROXIULN
ILIUMPUB
ISCHIPUB
ISCHILI
ISCHITUB
ILIACRES
PROXIFEM
LESSETRO
DISTAFEM
PROXITIB
DISTATIB
PROXIFIB
DISTAFIB
S1TOS2
S2TOS3
S3TOS4
S4TOS5
TODDLEFT
TODRIGHT
SUCHLEFT
SUCHRIGHT
AURILEFT
AURRIGHT
RibPhase
RibNo
MIDLAMBL
MIBLAMBR
LAMBDA
OBELION
ANTSAGIT
BREGMA
MIDCOROL
MIDCOROR
PTERIONL
PTERIONR
SPHEFROL
SPHEFROR
INFSPHTL
INFSPHTR
SUPSPHTL
SUPSTPTR
ENDOCORL
ENDOCORR
ENDOLAML
ENDOLAMR
INCISUTL
INCISUTR
ANMEDPAL
POMEDPAL
TRANPALL
TRANPALR
GPALFORL
GPALFORR
VENTRARC
SPUBCONC
ISPURARI
PREAURSU
AURISUEL
CURVSACR
GSCINOWD
FEMHEADD
HUMHEADD
NUICHALCR
MASTOIDP
SORBSHAR
SORBRISI
PROMGLAB
MENTALEM
SUMARAGE
SUMARSEX
AGERANGE
MinAge
MaxAge
AgeUnit
COMMENTS
Source

SUMMPARA Table:

Catkey*
Indiv
Trackno
Recr
EntryDATE
SummPara
Entry
Modtime
Rowversion

Pathology Table:

Catkey*
Indiv
TRACKNO
RECR
EntryDATE
PathType
BONECODE
SIDE
ASPECT
SECTION
OBS1
OBS2
OBS3
OBS4

OBS5
OBS6
OBS7
OBS8
OBS9
OBS10
Description
Entry
Source

CaseListProInvt Table:
CATKEY*
INDIV
TRACKNO
SkelInv
Handfoot
AgeandSex
DentInv
Dentmorph
Taphonomy
Pathology
PCMetrics
CranNonmet
Craniomet
CranShap
SummPara
MMS
Pending
Photography
Cranial_Rad
Date_started
Date_LastMod
Repatriated
Prefix
RepatEvalNeeded
Other_number
RepatGroup
RepatSeries
Case_officer
Catkey_Active
ProtVerbot
ExtraField
Inquire_Invtry
Entry_date
Entry
LabLocation
Cran
Mand
PC
BroughtintoLab
Returnedto Stor
TempRet
PendingComments
CatkeyComments
OldLoc
PercentDone
Entry2
ModTime

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