Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Humanities
Department of Historical and Classical Studies

Serina Lyngstad Griffioen

Health is Wealth?

Dietary-related conditions observed through comparisons of skeletal analyses from the Medieval cemeteries found at The Library Site (1973-1985) and Søndre gate (1970-1975).

Master's thesis in Archaeology
Supervisor: Axel Christophersen
Co-supervisor: Nina E. Valstrand
May 2022

N95419, SKJ351, Field FN, The Library Site. Photo: Serina L. Griffioen.

NTNU
Norwegian University of
Science and Technology

Serina Lyngstad Griffioen

Health is Wealth?

Dietary-related conditions observed through comparisons of skeletal analyses from the Medieval cemeteries found at The Library Site (1973-1985) and Søndre gate (1970-1975).

Master's thesis in Archaeology
Supervisor: Axel Christophersen
Co-supervisor: Nina E. Valstrand
May 2022

Norwegian University of Science and Technology
Faculty of Humanities
Department of Historical and Classical Studies

NTNU
Norwegian University of
Science and Technology

i. Abstract

The town of Trondheim, established in the 10th-11th century, experienced a rapid populational growth of both local, regional, and international people towards the 14th century. With the growing political, ideological, and economic functions of the town, the population adapted different societal roles, where some belonged to a higher socioeconomic class, and others did not. This thesis has attempted to see if there are any socioeconomic differences between two groups of individuals buried at the medieval cemeteries found at The Library Site (1973-1985) and Søndre gate (1970-1975), through skeletal analysis of 57 individuals (ca. AD 1150-1250) by focusing on dietary-related conditions. The conditions tackled in this study are cribra orbitalia (CO), porotic hyperostosis (PH), dental wear, calculus, abscess, caries, antemortem tooth loss (AMTL) and linear enamel hypoplasia (LEH). Generally, the individuals of The Library Site showed a higher frequency of CO and PH, and those of Søndre gate had a higher frequency of the tackled dental conditions. The overall results suggests that all individuals had a varied diet, however, not plentiful enough. Differences were found between the two sites, where the individuals of The Library Site seem to have been better-off, than those of Søndre gate. This is especially evident through the frequency of LEH. However, individual variation, teeth preservation, and the fact that cemeteries are often not as dichotomous as being for either the "rich" or the "poor", would affect the results. The conclusions and interpretations made in this thesis is therefore only representative for these individuals.

ii. Acknowledgments

This research has been conducted in association with the project Medieval Urban Health- From Individual to Public Responsibility, AD 1000-1600 (MedHeal600), and has contributed to shed some light on one of the projects research questions: "is it possible to identify differentiation from dietary differences between individuals and from dietary changes during an individual lifetime?". Thank you for the cooperation! This thesis has also exceeded the maximum word count, with 26 183 words written. This is due to the need of thorough presentations of methods, results, and discussions.

Nonetheless, this thesis would not exist without my supervisors, Axel Christophersen and Nina Elisabeth Valstrand. I am forever grateful for the opportunity to work with both of you, and for your help getting access to the human remains. Axel, thank you for always taking the time to discuss my thesis (and life in general), supporting me, and giving me the opportunity to join your dear project, MedHeal600. It has been a pleasure being your student! Nina, thank you for supervising me during the skeletal assessments, great conversations, and for giving me osteological pointers. You showed me what DORA-life was all about, which I will never forget. All in all, I could not have asked for better supervisors!

I would also like to extend my thanks to Birgitte Skar for allowing me to study the skeletal remains, and Terje M. Hellan for retrieving the requested sample. Moreover, thanks to Ruth I. Øien for providing illustrations, as well as the initial skeletal recording sheets.

Furthermore, I would like to thank every single person I have worked with at NTNU University Museum (Vitenskapsmuseet), especially those on the project of NIDARK. Thank you all for taking your time to discuss my thesis, your support, and for sharing your knowledge. It has been a pleasure working with you, and I hope to work with all of you in the future! Also, thanks to my dear friends from my stay in Oslo, especially Molly W. Wadstål and Ingeborg M. Hornkjøl, for always offering your help, believing in me, and for making my stay in Oslo memorable! In addition to this, I would like to thank my roommate and classmate Sara R. Langvik, for great conversations, friendship, and pointers to my thesis.

Also, I would like to extend my thanks to my mother, my sister; Linett, and my best friend Frida for believing in me.

Lastly, I would like to thank my amazing, supportive, and helpful partner, Lorentz. You have listened, advised, and helped me in so many ways. Thank you for essentially being a third supervisor, and for always being there for me. This thesis is dedicated to you.

Table of Contents

i. Abstract 0

ii. Acknowledgments 1

iii. List of Figures 4

iv. List of Tables 4

v. Acronyms and Terminology 5

1. Introduction 6

1.1. Research Questions and Aims 7

1.2. Limitations 8

1.3. Thesis Structure 8

2. Theory 9

2.1. What is Social Practice Theory? 9

2.2. Social Practice Theory and Foodways 10

3. Historical Review and Background 10

3.1. History of Human Osteoarchaeology and Paleopathology in Norway and Trondheim 11

3.2. The Town Emerges 13

3.3. Climate in 11th – Early 14th Century 15

3.4. Food in Medieval Trondheim, AD 1000 – 1300 16

3.5. The Library Site 1973-1985 & 1988-1989 18

3.6. Søndre gate 1970-1975 19

3.7. Summary 22

4. Methods 23

4.1. The Sample and its Representativity 23

4.2. Taphonomy and Fragmentation 25

4.3. Skeletal Analyses 25

4.3.1. Sex Estimation 25

4.3.2. Age Estimation 27

4.3.3. Pathology 28

5. Results 31

5.1. The Library Site 31

5.1.1. Age and Sex Distribution 31

5.1.2. Cribra Orbitalia (CO) and Porotic Hyperostosis (PH) 31

5.1.3. Dental Wear 33

5.1.4. Calculus 35

5.1.5. Abscess 36

5.1.6. Caries 36
5.1.7. Antemortem Tooth Loss (AMTL) 37
5.1.8. Linear Enamel Hypoplasia (LEH)...39
5.1.9. Summary 39
5.2. Søndre gate...40
5.2.1. Age and Sex Distribution...40
5.2.2. Cribra Orbitalia (CO) and Porotic Hyperostosis (PH) 40
5.2.3. Dental Wear 42
5.2.4. Calculus..45
5.2.5. Abscess 45
5.2.6. Caries...46
5.2.7. Antemortem Tooth Loss (AMTL) 47
5.2.8. Linear Enamel Hypoplasia (LEH)...48
5.2.9. Summary 50
5.3. Both Sites 51
6. Discussion 52
6.1. Each Observed Condition 52
6.2. The Conditions in Relation to Each Other: Socioeconomic Differences Between the Sites? 64
6.3. Variations Over Time, Individual Variations, and the Osteological Paradox 67
7. Conclusion...70
8. References 71
Appendix. 1: Chosen Individuals Based on the Initial Recording Sheets 83
Appendix. 2: An Overview of the Individuals Assessed from The Library Site................85
Appendix. 3: Overview of the Individuals Assessed from Søndre gate 87

iii. List of Figures

Figure 1: Map over where Trondheim is situated in Norway 13
Figure 2: NIdarnes peninsula 14
Figure 3: The Library site situated in Trondheim 18
Figure 4: Subfields of The Library Site excavations. 18
Figure 5: Field A and its subfields. 21
Figure 6: All the excavated fields in 1970-75 in connection with Søndre gate. 22
Figure 7: Cribra orbitalia 32
Figure 8: Number of teeth in each wear category, The Library Site 34
Figure 9: Calculus 36
Figure 10: Number of teeth lost antemortem and degree of healed alveoli, The Library Site 38
Figure 11: Antemortem tooth loss 38
Figure 12: Porotic hyperostosis 42
Figure 13: Number of teeth in each wear category, Søndre gate. 43
Figure 14: Dental wear 44
Figure 15: Abscess 45
Figure 16: Caries 47
Figure 17: Number of teeth lost antemortem and degree of healed alveoli, Søndre gate.. 48
Figure 18: Linear enamel hypoplasia 50

iv. List of Tables

Table 1: Criteria made for choosing individuals. 24
Table 2: Sex and age distribution, The Library Site 31
Table 3: Degree of CO for each sex and age-categories, The Library Site 32
Table 4: Degree of PH for each sex and age-category, The Library Site 33
Table 5: Number of teeth and their degree of dental wear, The Library Site 34
Table 6: Distribution of number of preserved teeth, The Library Site 35
Table 7: Distribution of the degree of calculus formation, The Library Site 35
Table 8: Present carious lesions, The Library Site 37
Table 9: Number of teeth lost antemortem and the degree of healed alveoli, The Library Site 37
Table 10: LEH on each tooth, The Library Site 39
Table 11: Number of linear stripes on each tooth, The Library Site 39
Table 12: Age and sex distribution, Søndre gate 40
Table 13: Distribution of the degree of CO according to sex and age, Søndre gate 41
Table 14: Distribution of the degree of PH according to sex and age, Søndre gate 41
Table 15: Number of teeth and their degree of dental wear, Søndre gate 43
Table 16: Distribution of number of preserved teeth, Søndre gate 44
Table 17: The distribution of the degree of calculus formation, Søndre gate 45
Table 18: Present carious lesions, Søndre gate 46
Table 19: Number of teeth lost antemortem and the degree of healed alveoli, Søndre gate 48
Table 20: LEH on each tooth, Søndre gate 49
Table 21: Number of linear stripes on each tooth, Søndre gate 49
Table 22: Overview of the results and interpretations of them 67

v. Acronyms and Terminology

CO: Cribra Orbitalia

PH: Porotic Hyperostosis

AMTL: Antemortem Tooth Loss

LEH: Linear Enamel Hypoplasia

YA: Young adult

MA: Middle adult

MWP: Medieval Warm Period

LIA: Little Ice Age

CEJ: Cementoenamel Junction (the border of the enamel of the crown and the cementum of the root).

Distal surface of tooth: The surface that is away from the midline of the face (interproximal)

Mesial surface of tooth: The surface that is closest to the midline of the face (interproximal)

Labial surface of tooth: The surface towards the lips

Buccal surface of tooth: The surface towards the cheeks

Lingual surface of tooth: The surface that faces the tongue

Incisal surface of tooth: The biting edge of an incisor or canine

Occlusal surface of tooth: The chewing surface of premolars and molars

1. Introduction

Established in the 10-11th century, Trondheim flourished, and local, regional, and international people filled the town. With the growing political, economic, and ideological functions, Trondheim experienced a rapid populational growth towards the 14th century. As the climate was warmer due to the Medieval Warm Period (MWP), the population also experienced agricultural and climatic prosperity, making it possible to cultivate crops to previously unfarmed land (Lamb, 1995, pp. 160-163). A lot of different foodstuffs were available, like different types of grains, vegetables, fruits, and berries. Being situated on the coast, seafoods were probably greatly consumed, such as fish, seal, and whale. Herding animals was also not uncommon; osteological evidence suggests that cattle, goats, sheep, pigs, and poultry were both consumed and kept for secondary products (such as milk). With this, the people of ca. AD 1000-1300 would seem to live in prosperity in the growing town of Trondheim. With populational growth, however, new bacteria, diseases, ideologies, and customs follows. The living situations would probably have been more cramped, causing infectious diseases and parasites to spread more rapidly. In addition to this, based on tree-rings and historical records, the 13th century emerged with several years of crop-failure. This got further accentuated after 1258, when a volcano erupted and thereby affected several parts of the world. With this, it could have resulted in famine, disease, social and political unrest (Stothers, 2000, pp. 361-362). Thus, with the Little Ice Age (LIA) emergence in the late 13th-14th century, it stood in stark contrast to previous years. With the deteriorating and cooler climate, the general health, food availability and economy would also have been affected.

As just presented, food availability and consumption, climate, migration, diseases, and parasites are all connected to each other, and would serve as multiple explanatory reasons for the occurrence of dietary-related conditions. However, these are not the only explanations, as social choice, food preference, and genes also play a central role in the consumption and absorption of food and nutrients. Few studies have previously been conducted on this topic for the medieval population of Trondheim, Allison Cairns (2015) being one of these. Therefore, it was decided to contribute to the research of dietary-related conditions in this population. Moreover, with the ongoing project of Medieval Urban Health- From Individual to Public Responsibility, AD 1000-1600 (MedHeal600), it is expected that more studies on this topic will continue to rise, this thesis being one of them.

1.1. Research Questions and Aims

This thesis seeks to assess and compare two groups of human remains from two cemeteries (The Library Site, 1973-1985 and Søndre gate, 1970-1975), in order to identify and analyze traces of dietary-related conditions from the period ca. AD 1150-1250, and shed some light on the etiology of the frequency of these conditions.

In order to approach this, four questions were put forward:

1. Which dietary-related conditions is evident in the chosen skeletal sample?
2. Do the results show any differences between the two sites when it comes to dietary-related conditions?
3. Which factors could have contributed to affect the diet, and so forth have contributed to cause these conditions and the seen differences/no differences?
4. Based on this sample, can these dietary-related conditions reflect different socioeconomic statuses between the sites?

First and foremost, to answer these questions, two groups of individuals were chosen from the cemeteries located at The Library Site and Søndre gate respectively. These sites were chosen due to a hypothesis on socioeconomic differences between these sites; while these cemeteries are both thought to represent the middle class, the individuals from The Library Site are thought to represent the upper-middle class, with those of Søndre gate representing the lower (Personal communication, Axel Christophersen, 08.09.2020). This is based upon the placement of the sites in connection to the medieval street system, as well as the material culture found at the sites: The Library Site is situated in proximity of the medieval street called *Kaupmannstrete* ("the street of merchants") which included merchants, while Søndre gate is situated next to the medieval street of *Langstrete* ("the long street") which entailed craftsmen (Christophersen, 2020, pp.181-185). With this, seeing if dietary-related conditions could reflect this socioeconomic difference would prove to be interesting. To distinguish between these socioeconomic groups, the thesis is based upon the following hypothesis:

"The higher socioeconomic class one belongs to, the more varied, regular, and sufficient diet one has. Consequently, fewer dietary-related conditions will appear in the human skeletal remains".

Furthermore, 57 individuals have been assessed under the supervision of Nina E. Valstrand, wherein 30 were from The Library Site and 27 were from Søndre gate. Prior to the analysis of human skeletal remains, ethical evaluations were undertaken by one of the participants of The National Committee for Evaluation of Research Involving Human Skeletal Remains (The Skeletal Remains Committee), as well as by the author herself both prior to and during the analysis. The research was so forth undertaken at the ex-World War 2 submarine facility, "DORA", where the individuals are stored. The conditions tackled in this study are cribra orbitalia (CO), porotic hyperostosis (PH), dental wear, calculus, (dental) abscess, caries, antemortem tooth loss (AMTL) and linear enamel hypoplasia (LEH).

1.2. Limitations

As there are several ways of establishing health and diet in human remains, some limitations are in place. First of all, a sample of 57 individuals is not much, and does not represent all the individuals (except themselves) of both sites, or medieval Trondheim as a whole. The aim is not to make a demographic profile of Trondheim or the sites, but rather to see if there are any indications of socioeconomic differences between the sites, even in a small sample. With this research, I will contribute to the continuous bioarcheological research in Norway and more specifically, Trondheim, and shed some light on the necessity of such research in archaeology. Secondly, the thesis is limited by the type of analyses and pathologies. During this research, only visual analyses were undertaken, and no destructive or radiographic analyses of any kind were performed. Furthermore, to assess health and social status based on food consumption, there are other features and factors to look at, for example Harris lines (growth arrest lines) and stature. Given that Harris lines are only visible by radiography or in cross-section of the bone, it was excluded from the thesis, as only visual analyses took place. Moreover, stature was excluded due to the small sample size, as well as the extent, and limitations of this paper. In addition to this, the interpretation of stature in the past is complex, as the catch-up effect, which refers to that children and juveniles may recover from linear growth arrest through increased growth rates and/or delayed maturation, may confound the evidence (Vercellotti et al., 2014, pp. 230-240). Further research on both stature and Harris lines in connection to the tackled conditions in this thesis is however encouraged.

Lastly, due to the at times challenging diagnostics of scurvy and osteomalacia in adult human remains (Ortner & Putschar, 1981; Güllü et al., 1998; Lips, 2001; Melikian & Waldron, 2003; Maat, 2004; Brickley & Ives, 2008; Geber & Murphy, 2012; Brickley & Mays, 2019), these conditions were not distinctively and positively observed in the assessed sample, and thus not further explored in this thesis. With this, most of the dietary-related conditions tackled are limited to the oral health.

1.3. Thesis Structure

Following the introduction, the utilized theory for this thesis will be presented in chapter 2. This entails social practice theory, which will be used as a framework during the discussion of the frequencies of the observed conditions.

Chapter 3 includes both a historical review of osteoarchaeology, and a background of Medieval Trondheim. The historical review starts out with focusing on osteoarcheology in Norway, followed by previous osteological research done in Trondheim, with focus on paleopathology and the addressed conditions in this thesis. The next part presents the background of Trondheim, with focus on the town's emergence, its climate and food sources. Furthermore, the background of the two chosen sites will be presented.

Chapter 4 starts out with a reflection of the representativity of the individuals and the process behind selecting them. Furthermore, it includes all the utilized methods during the research on human remains, including taphonomy and fragmentation, estimation of sex and age, and lastly, pathology.

Chapter 5 contains all the results of the 57 individuals, starting out by addressing the results from The Library Site, then Søndre gate, and at last both sites combined.

Chapter 6 entails the discussion of the results presented in chapter 5, by first discussing each condition separately. What does each condition imply when it comes to food consumption and social statuses, when not taking the other dietary-related conditions into account? The second part of the discussion looks at all the conditions combined and proposes an interpretation with all the available information from previous discussion. Lastly, the third part discusses the implications of establishing socioeconomic statuses based on two cemeteries and paleopathology, as well as how individual variation affect the results and interpretations.

Finally, chapter 7 concludes the whole thesis, where the conclusions found in the discussion will yet again be presented.

2. Theory

For this research, theory will be used as a framework for the discussion. This is due to the fact that different types of practice could all contribute to the presence or absence of different dietary related conditions observed in skeletal remains. The emphasis of this chapter will therefore be how social practice theory could contribute to interpret the obtained data for this thesis, with focus on foodways. With 'foodways' I refer to the cultural, social, and economic practices related to food consumption, choice, and production.

2.1. What is Social Practice Theory?

Social practices refer to everyday practices and their importance in both the maintenance and alteration of cultural systems and the negotiation of social identities (Reckwitz, 2002; Shove, Pantzar & Watson, 2012). In many ways, practice theory is bridging the gap between broader social structures and individual agents, which is also evident in Giddens' structuration theory. It revolves around the conclusion that human activity, and the social structures which shape it are recursively related, as Giddens' states "*the constitution of agents and structures are not two independently given sets of phenomena, a dualism, but rather represents a duality*" (Giddens, 1984, pp. 25). Practice theory is in part built on this duality and pushes Giddens' structuration theory even further by including an attempt to unfold questions on how practices emerge, evolve, and disappear (Shove et al., 2012, pp. 3). The theory argues that within any given society there exists institutions and activities which are regulated by societal rules and norms, and that human actions are carried out within this preexisting social structure and may therefore be somewhat confined. Individuals are however not powerless in these settings, as they maintain some degree of agency through practice, experiences and knowledge which can manifest through subtle movements (i.e., mannerisms, tastes, utterances) or everyday activities (e.g., food preparation and consumption, bargaining, gift exchange). This can result in long-term practice developments and lead to institutional and/or social change, as well as the routines of everyday life (Schrader, 2019, pp. 20-21). One could therefore say that modern practice theory seeks to explain the relationship(s) that occurs between human action (as routinized practices) and global entities such as social, economic, political, religious, and ideological norms, traditions, and perspectives (Ortner, 1984; Schrader, 2019).

2.2. Social Practice Theory and Foodways

The study of food has had an increased interest amongst scientists from all kinds of fields (i.e., archaeology, sociology, history, anthropology, and nutritional sciences). While archaeological evidence and sciences may provide data of food in the past, sociology and anthropology offers models of interpretation of these data (Woolgar, 2010, pp. 2-3). A model as such, is the previously mentioned social practice theory. While being an umbrella term (see Reckwitz, 2002, pp. 243-244), social practice theory with focus on food could illuminate questions such as "could there be a socioeconomic difference present through the consumption of food, and why?", "could different food sources have had different social statuses?", and "is there a difference between the sexes, and why?". Bourdieu (1984), although criticized (E.g., see Lamont & Lareau, 1988; Erickson, 1996; Bryson, 1996), wrote extensively on food and taste in relation to capital. In his research he asserts that individuals with a high volume of cultural capital within their own social context, effectively define taste. He further states that those who have a lower volume of cultural capital, have no choice but to accept this interpretation of taste. According to Bourdieu, this gets legitimized and accepted as dichotomous forms of "high" and "low" culture, where the individuals in the low culture category are being enabled to engage with the high culture tastes (Bourdieu, 1984; Schrader, 2019). However, in studying the nature of food, one must not overlook individual actors, which one could argue that Bourdieu does in his study of taste and capital. Sure enough, his theory could be applied for smaller social groups or families, yet that does still not include the individual as someone with its own tastes, ideas, and role. Fischler (1988) points out the importance of individual identity in food choice, and while this choice could be extrapolated to societies, one must be aware that the basic food choices are often made at the level of the individual, as well as by the collective norms and traditions (Fischler, 1988, pp. 275). Foodways goes beyond simply reflecting society, dietary choice, and consumption, and should rather be viewed as a method of creating society through the actions of individuals (Hodder & Hutson, 2003; Schrader, 2019). When it comes to foodways, society, individuals, culture, religion, and economy all influence each other in a mutual relationship, and is not as dual as Bourdieu's theory of taste and capital. Based on this, social practice theory would serve as a beneficial theory for the upcoming interpretations found in this thesis.

3. Historical Review and Background

In chapter 3, both a historical review and a background of Trondheim will be explored. Starting off with a brief historical review of osteoarchaeology in Norway, chapter 3.1. ends with a research history of the human osteoarchaeological work previously done in Trondheim (with focus on the pathological conditions tackled in this paper). Furthermore, there will be light shed on some of the early history of Trondheim (ca. AD 1000-1350), its climate and food sources. Lastly, a more in depth look at the two medieval cemeteries which the analyzed skeletal remains stem from, will take place.

3.1. History of Human Osteoarchaeology and Paleopathology in Norway and Trondheim

In this chapter a brief history of osteoarchaeology in Norway will be reviewed before the research history in Trondheim with focus on paleopathology is further explored. Two terms will be introduced, -physical anthropology and osteoarchaeology- where the former is mostly concerned with the biological aspects of anthropology, including the study of fossil human beings, genetics, primates and blood groups, and the latter deals with the study and analysis of human and animal skeletal remains, in the context of archaeological deposits. Henceforth, osteoarchaeology is the applied term for this thesis.

Historical Review of Human Osteoarchaeology in Norway

From the 1850's onwards, anthropological studies were carried out by practitioners of medicine (primarily anatomists) with the goal to map the population anthropologically based on morphological studies (Kyllingstad, 2004; Sellevold, 2014). In 1851, the first archaeological skeletal finds were rescued and preserved for further scientific study and were the first archaeologically derived human remains to be included in the skeletal collection (established in 1828) of the University of Christiania (Oslo) (Sellevold, 2014, pp. 18-19.). According to Sellevold (2014) (which is based on Næss & Sellevold, 1990) the activities in physical anthropology and osteoarchaeology may be divided into four periods: "the anthropological", "the antiquarian", "the archaeological" and "the osteoarchaeological".

The "anthropological" period (1912-1945) is characterized by the gathering and collection of human skeletal remains by the anatomists themselves. Anatomists all over the country promoted the collection of skeletal remains in order to use this for their research (Næss & Sellevold, 1990; Sellevold, 2006; Sellevold, 2014). One of these anatomists was Professor of anatomy Kristian Emil Schreiner, who both encouraged graveyard diggers to send in the skeletons and organized excavations himself (See Kyllingstad, 2004 for more). His work resulted in several publications, and towards the end of 1970's, after his death in 1954, the anthropological collection at the University of Oslo was named after him (The Schreiner Collection) (Næss & Sellevold, 1990; Sellevold, 2006; Sellevold, 2014).

The "antiquarian" period (1945 – mid-1980's) on the other hand, was characterized by excavations of human skeletal remains being carried out by antiquarians, first and foremost *Riksantikvaren* (The Directorate of Cultural Heritage) (Næss & Sellevold, 1990; Sellevold, 2014). In the early 1970's, *Riksantikvaren* established excavation units in the medieval towns of Trondheim, Bergen, Oslo and Tønsberg in connection with road constructions and building activities (Sellevold, 2006, pp. 13). During these excavations the uncovered human skeletal remains were not lifted for research purposes (such as during the "anthropological" period), as they were disinterred in order to "rescue" the human remains due to a lot of emergency excavations in the medieval towns. Often these remains were reburied, and during these years there were few research projects involving human remains (Sellevold, 2011; Sellevold, 2014). In 1986 the Schreiner Collection was closed for new finds when DAIK (The Archaeological Interim Committee) decided to not continue the general practice of depositing skeletal remains in the collection. From then on, human remains were deposited in the magazines of the five archaeological museums (*Landsdelsmuseene*) in Oslo, Stavanger, Bergen, Trondheim and Tromsø (Sellevold, 2014, pp. 21).

Following the "antiquarian" period, the "archaeological" period continued from the mid-1980's and towards 1994. At this point, it was the archaeologists themselves who began to take responsibility for skeletal finds from archaeological investigations (Sellevold, 2006; Sellevold, 2014). In 1986, a report on the state of human osteology in Norway was commissioned by DAIK, with the result of measures being taken to improve the curation of the human remains. Furthermore, an "osteology group" (*Osteologisk Samarbeidsgruppe*) and a "Physical Anthropology Work Unit" (*Fysisk Antropologisk Oppdragsenhet*) were established in 1990, where the objective of these groups was to organize the work dealing with human and animal remains from archaeological contexts, as well as teaching, excavations, and project work (Sellevold, 2014, pp. 21-22).

Lastly, the "osteoarchaeological" period (1994-present) emerged. In 1994 the Norwegian Institute for Cultural Heritage Research (NIKU) was established, where the responsibility of archaeological human remains was transferred to this new institute (however, the curatorial responsibility was still assigned to the five university museums) (Sellevold, 2011; Sellevold, 2014). "The osteology group" and "the Physical Anthropology Work Unit" were dissolved, and the term "physical anthropology" went out of use and was replaced by the term "osteoarchaeology" (Sellevold, 2014, pp. 22-23). In 2007, The National Committee for Evaluation of Research Involving Human Skeletal Remains (The Skeletal Remains Committee) was established due to the need of a national committee to address questions concerning storage of, and research on, the Sami human remains at the Schreiner Collection (Sellevold, 2011, pp. 325). To this day the Skeletal Remains Committee handles amongst others, requests of research on human skeletal remains, and gives the requested research an ethical evaluation (Fossheim, 2012, pp. 7-9). However, this committee is only advisory, and it is the university museums themselves that has the final saying in research conducted on osteoarchaeological remains.

Research History of Osteoarchaeology and Paleopathology in Trondheim

Several scientists have analyzed the medieval skeletal remains of Trondheim (i.e., Anderson & Göthberg, 1986; Beyer-Olsen, 1989; Sellevold, 1990; Beyer-Olsen & Risnes,1994; Hanson & Miller, 1997; Hamre, 2011; Cairns, 2015; Hamre & Daux; 2016; Hamre, 2017; Hamre, Ersland, Daux, Parson & Wilkinson; 2017), however not many have focused on morphological changes and conditions related to diet. While Anderson & Göthberg (1986) and Sellevold (1990) remarks pathologies such as arthritis, they mention almost none of the conditions studied in this thesis, with exceptions of dental wear, caries and LEH. However, these are not further explored in their publications, and are limited to the individuals of The Library Site. Furthermore, analyses by Hamre (2011) and Hamre et al. (2017) addresses health in medieval Trondheim (with mentions of CO and PH), but are however, yet again, limited to The Library Site excavations. Thus, one might argue that because of the limitation by site, i.e., the human remains, the individuals buried at The Library Site is overrepresented (Valstrand, 2022) in what we today know about people and health in Medieval Trondheim (for more examples of research on the skeletal samples from The Library Site, see Beyer-Olsen, 1989; Beyer-Olsen & Risnes, 1994). However, there are some publications on the skeletal remains of Trondheim that includes other sites as well. Hamre & Daux (2016) by example, includes several other excavation sites such as *Søndre gate*, *Vår Frue Kirke*, *Vestfrontplassen* and

Servicebygget, however their focus is on migration patterns and not dietary-related conditions. Cairns (2015) addresses both infectious diseases and the dietary-related conditions explored in this research, and includes human remains from both The Library Site and The Nidaros Cathedral (although she only did her own analysis of The Library Site, and the assessments from The Nidaros Cathedral were based on the works of Reed, Kockum, Hughes & Sandvik, 1998). Apart from this, Hanson & Miller (1997) have done research on LEH in Scandinavia, with teeth from the skeletal remains of Trondheim (and what is believed to be from Søndre gate, see Cairns, 2015 for discussion on this).

Currently the project "Medieval Urban Health- From Individual to Public Responsibility, AD 1000-1600 (MedHeal600)" is ongoing (NTNU University Museum, 2017), and has and will contribute to the research of health in Medieval Trondheim (i.e., see published article from Fotakis, et al., 2020). Thus, both the ongoing research in MedHeal600 and this thesis, will contribute to the continuous research development in human osteoarchaeology and paleopathology for Medieval Trondheim.

3.2. The Town Emerges

Trondheim is situated on the west coast of Norway, in the municipality of Trøndelag and on the southern shore of the Trondheimsfjord. Also known as Nidaros during the Middle Ages, Trondheim was the capital of Norway until AD 1217. However, how, and when did this town emerge? This chapter is going to shed some light on the development of the town - from its beginning to ca. AD 1350.

Figure 1: Map over where Trondheim is situated in Norway (large black spot). Illustration: Norgeskart (kartverket), modified by Serina L. Griffioen

The early settlements of what became the town of Trondheim, were situated on Nidarnes – a peninsula surrounded by the River Nid and the Trondheimsfjord (figure 2). From the Iron Age on, settlements in the surrounding areas of Nidarnes were already present, by example in Klæbu, Tiller, Strinda and Byneset (Christophersen & Nordeide, 1994, pp. 41). Vegetational reconstructions based of pollen shows that the fields of Nidarnes in the 10th-11th century were used for grazing and agricultural purposes (grains), and also included untouched meadows (Selvik, 1986; Bjerck & Hansson, 1988; Petersén, Sandvik & Sveistrup, 2015; Jantsch, 2017). Furthermore, ard marks show an even earlier agricultural settlement on Nidarnes. ^{14}C-dating suggests that some acres were already in use from the early 10th century, and pollen analyses of these ard marks showed, amongst others, traces of grains (Bjerck & Hansson, 1988; Petersén, Sandvik & Sveistrup, 2015).

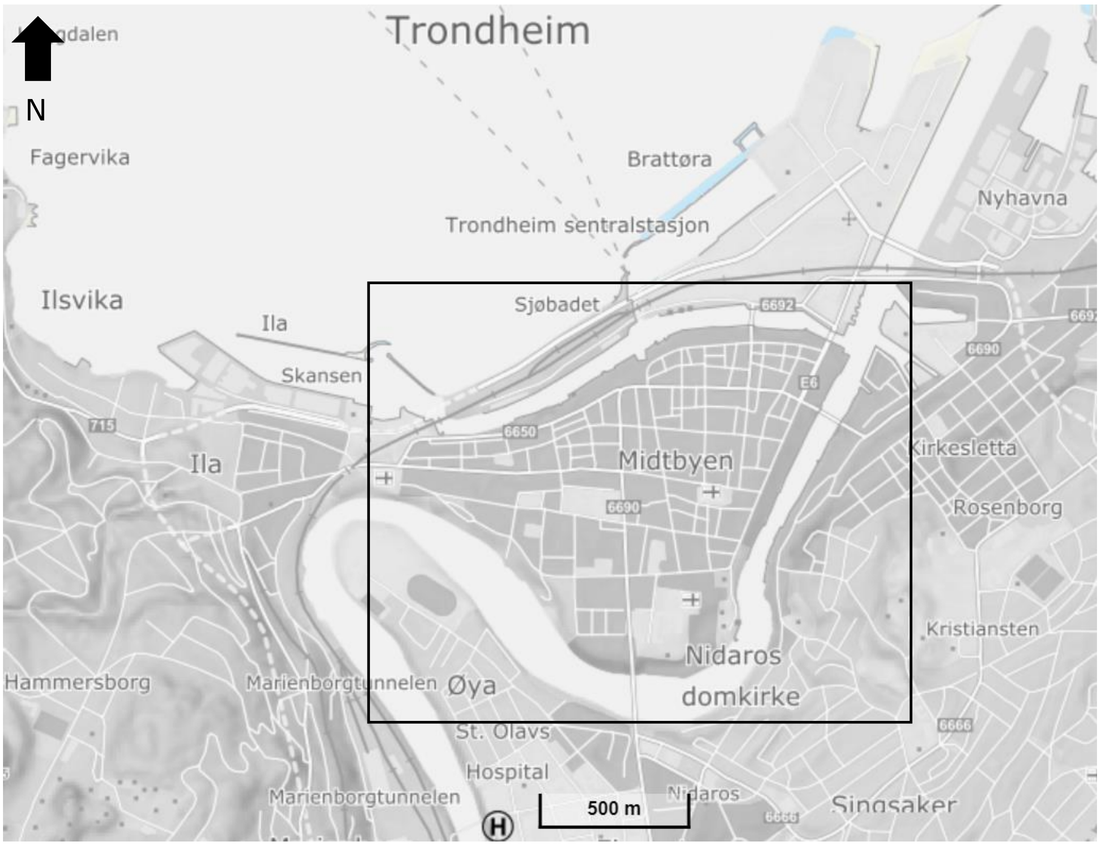

Figure 2: Nidarnes peninsula (called Midtbyen today) and the River Nid today. illustration: Norgeskart (kartverket). Modified by Serina L. Griffioen

Furthermore, during the 10th century a harbor was established in the mouth of the River Nid, which soon developed into a marketplace called *Kaupangen* (Christophersen & Nordeide, 1994; Christophersen, 2020; Cadamarteri, McLees, Petersén & Reed, 2020). Soon after, Olav Haraldsson came to power, and the days of the Earls of Lade (*ladejarlene)* were gone. During the early 11th century King Haraldsson (Saint Olaf) had brought a royal residence and a church to the marketplace, and with this he made *Kaupangen* a center for both the church and to the royals. As soon as the churches were built, the commerce also increased. Furthermore, after his death in AD 1030, and the title of saint was given, pilgrims and other local, regional, and international people filled the town, and *Kaupangen* grew into *Kaupstad*. Nidarnes became so forth an urban settlement, with political, ideological, and economical functions (by example, The Norwegian Archbishopric was established in 1152), and the town of Trondheim emerged

(Holt, 2007; Christophersen, 2020). Trondheim grew as a town through the 12th and 13th centuries, and it is suggested (as a minimum amount) that around 2600 people lived in Trondheim AD 1200, and by AD 1300, the town reached its populational peak, with ca. 3200 people. From the 14th century onwards, however, with the bubonic plague sweeping through the town, both the town and its population declined (Holt, 2007; Christophersen, 2020). However, such a rapid populational growth would have brought its challenges. The amount of food necessary to feed the entire population would have been greater, the living situation would have been more cramped and confined, and thus, it may also have led to a greater socioeconomic difference amongst the population. With more cramped living situations, infectious diseases and parasites could spread more rapidly, which could, in addition to a lack of food, contribute to the development of certain conditions. Thus, it is of importance for further interpretations.

3.3. Climate in 11th – Early 14th Century

"The Medieval Warm Period" (MWP) is a frequently used term to describe a period of warm climate in, amongst others, the North-Atlantic region, which is relative to the periods before and after (Christophersen, 2020, pp. 307). According to Hubert Lamb (1995) the MWP occurred in Northern Europe between AD 1000-1300, which lasted until the beginning of the high Middle Ages for the region of Trøndelag. This dating is based on pollen studies of wheat in Trøndelag, which shows that the cultivation of it abruptly ceases by the end of the 13th century (Lamb, 1995, pp. 161). However, determinations of the timing of MWP appear to be highly dependent on geographical location. According to historian Audun Dybdahl (2010) the MWP emerged in the region of Trøndelag around the time of the Battle of Stiklestad in AD 1030, and lasted until the beginning of the 13th century. In Dybdahl's study, he uses both historical records and dendrochronological research (tree rings) to legitimize these dates and emphasizes that even though this was a so-called "warm period" (which it was compared to other continents and earlier periods; see Lamb, 1995), it does not exclude years of crop failure and famine. He further states that some of the years of crop failure and possible famine in the 12th century, despite being a relative warm and stable climatic period, are AD 1136, 1182 and 1191 (Dybdahl, 2010, pp. 207-210). The 13th century emerged with several more years of crop failure and famine, being in 1206-1207, 1211-1213, 1236-1238, 1243 and 1258. Of these years, 1258 stands particularly out (Dybdahl, 2010, pp. 211-212). According to Richard B. Stothers (2000) a volcano erupted somewhere in the tropics in 1258, bringing with it a so called 'dry fog' that would have lasted for several years. This dry fog, layering the earth's atmosphere, would have blocked some of the sunlight and cooled the earth's surface. With this, an increase of precipitation would have affected the agriculture, and thus resulted in possible famine, disease, social and political unrest (Stothers, 2000, pp. 361-362). This event is evident in tree-ring widths in Norwegian and Swedish pine chronologies, as the width declined for approximately a decade from 1258 (Thun & Svarva, 2018, pp. 28). Therefore, this volcanic eruption had widespread consequences.

During the Middle Ages, the population of Trøndelag purportedly experienced extreme weather conditions, beginning with the MWP, a time of great agricultural prosperity when farmland and cultivation of crops were extended to previously unfarmed lands (Lamb, 1995, pp. 160-163). However, following this period came the Little Ice Age (LIA), which refers to a period of glacial extension (Grove, 2001, pp. 53). Studies of cores from the Greenland ice sheets and marine sediment records indicated glacial advances and periods of cold occurring in the late 13th and 14th century (Grove, 2001, pp. 68-69).

Dendrochronological analyses of summer temperatures in pine tree (*pinus sylvestris)* in Norway also indicated that the coolest period occurred from around the 14th century and lasted towards the 19th century (Helama et al., 2009, pp. 453). Terje Thun & Helene Svarva (2018) discusses in their study of tree-rings in Norway (Oslo and Trondheim) that the demographic crisis in Norway started several decades before the onset of the Black Death. The climatic deterioration caused amongst others, heavy rainfall, and cold spells, and would have had a great effect on crop failure, especially in farms growing grains at its altitudinal and latitudinal limits, which was the case for many late medieval farms in Norway (Thun & Svarva, 2018, pp. 28). Thus, the bubonic plague probably hit a population that was already in decline.

To conclude, as seen in this chapter the climate has fluctuated between warmer and cooler periods. This is evident with years of agricultural prosperity, crop failure and famine, and eventually, by the end of the 13th century, the climate gradually turned cooler, and a new climatic cycle had begun. This deteriorating climate could have contributed to a populational decline, due to starvation and/or decreased health (due to cold temperatures, more precipitation, less food etc.), especially in those belonging to a lower socioeconomic class. With this said, the climate would have contributed to cause several stressors that could be evident in the skeletal remains (i.e., LEH), thus, the climatic events would play an important role in the interpretations of the tackled conditions.

3.4. Food in Medieval Trondheim, AD 1000 – 1300

In this chapter different foodstuffs available in AD 1000-1300 Trondheim will be presented, starting with plant-based foods, dairy products, and beverages, and ending with terrestrial and marine foods with a focus on meat consumption.

Grains, Vegetables, Fruits, Berries, Beverages, and Dairy Products (1000-1300)

Ingvild Øye (1998) suggests that parts of the urban landscape in Trondheim had been used for agricultural purposes, specifically for grains and/or "cabbage-gardens" (fenced gardens) (Øye, 1998, pp. 33-34). Pollen analyses shows that different types of grains were cultivated, such as barley (*Hordeum vulgare*), oat (*Avena sativa*), rye (*Secale cereale*) and even wheat (Triticum) (Selvik, 1986; Griffin & Sandvik, 1989; Lamb, 1995; Øye, 1998; Sandvik & Selvik, 1999; Christophersen, 2020). As for the so-called "cabbage-gardens", Øye (1998) acknowledges that there has been no palaeobotanical discovery of this in Trondheim, but refers to laws implemented for, amongst others, Trondheim (*Bjarkøyretten* and *Landsloven)* which mentions onions (*allium sp*.), garden angelica (*Angelica archangelica*) and cabbage (*Brassica oleracea)* (Øye, 1998, pp. 14-16). However, pollen analyses from excavations at *Torvet in Trondheim* (2015-2017) found amongst other traces of beans (*Vicia-type*) in a medieval layer, and macroplant analysis found cabbage in a postmedieval layer (Brassica sp.) (Personal communication, Julian Cadamarteri, 22.02.2022), which is indicative of vegetables at least being present, if not cultivated in such fenced gardens. Other fruits, vegetables, nuts, and berries found in Trondheim include beans *(Vicia faba),* rosehip (*Rosa sp*.), crowberry (*Empetrum sp.*), bunchberry *(cornus suecica)*, cloudberry (*Rubus chamaemorus*), raspberry (*Rubus idaeus*), blueberry *(Vaccinium myrtillus),* wild strawberry (*Fragaria vesca*), bog bilberry *(Vaccinium uliginosum),* cranberry (*oxycoccus quadripetalus*), rowan (*Sorbus aucuparia),* apple (*Malus sp.*), blackberry (*Rubus*), hazelnuts and walnuts (imported) (Griffin & Sandvik, 1989; Øye, 1998; Sandvik & Selvik, 1999; Sæhle, et al. 2021). Thus, it seems reasonable that some of these elements were consumed in one way or another.

As for beer and wine, beer was mostly made locally as traces of both hop (*Humulus*) and bog myrtle (*Myrica gale*), - two herbs important in flavoring beer-, are found at several excavation sites, and even traced back as far as AD 1000 (Griffin & Sandvik, 1989; Øye, 1998; Sandvik & Selvik, 1999). Wine on the other hand, had to be imported, and was available to most of the population of Trondheim (Christophersen, 2020, pp. 322). Based on The Library Site material, Christophersen & Nordeide (1994) discusses that most of the production and commerce in Trondheim occurred between AD 1100 – 1300, and Christophersen (2020) refers to both drinking vessels and a speech held by King Sverre in 1186 in Bergen to support his conclusion on both the import and availability of wine in Trondheim. In addition to this, milk, and dairy products such as butter, skyr and cheese were probably consumed on a great level (Øye, 1998; Christophersen, 2020), as several of the bones of cattle from the 11th century shows that over 40% reached an age higher than 4-5 years, and 25% over 7 years (Lie, 1989, pp.16).

Terrestrial and Marine Foods: Meat Consumption

The osteological evidence suggests that cattle (*Bos taurus dom*.), goats (*Capra hircus*), sheep (*Ovis aries*), pigs (*sus. scrofa*) and poultry (various species, see Lie, 1989 for more details) were all a part of the medieval diet. Of this, cattle dominate, which may stem from the fact that one cattle probably represented as much as six sheep or three pigs when it comes to meat consumption (Lie, 1989; Øye, 1998). Other finds of terrestrial mammals include deer (*Cervus elaphus*) and reindeer (*Rangifer tarandus*), which were probably brought to the town due to their source of food and/or skin (Lie, 1989; Christophersen, 2020).

When it comes to marine food, several species of fish dominate, especially cod *(Gadus morhua) (*Lie, 1989; Christophersen, 2020). Other species of fish includes saithe *(Pollachius virens*), common ling (*Molva molva*), whiting (*Merlangius merlangus*) and Atlantic bluefin tuna (*Thunnus thynnus*). The latter, however, may stem from import of stockfish, as a larger ratio of fin bones are found compared to crania (Lie, 1989, pp. 25). Except for fish, several shells (mussels by example) are found, although these could stem from several causes and is not directly equivalent to consumption (Griffin & Sandvik, 1989). Besides this, several larger marine mammals are found, such as seal (*Pinnipedia*) and whale (particularly bowhead whale (*Balaena mysticetus*), toothed whales (*Odontoceti*) and baleen whales (*Mysticeti*)) (Lie, 1989; Christophersen, 2020).

With this, the selection of different food sources was rather diverse in Trondheim. With a balanced mixture of grains, fruit and berries, vegetables, dairy products, red and white meats, and marine foods, the population of Trondheim would have had access to a diverse and balanced diet. That being said, the climate plays an important role in the growth and availability of food sources. Thus, although the palaeobotanical and zoological remains paints a diverse food-picture, this does not exclude years of famine, crop failure and at times a reduced food stock. How the social structure of foodstuffs was organized, and which foodstuffs were available and/or affordable to certain groups or people, is also unknown. By looking at conditions that may be caused by a lack of vitamins and/or a certain intake of foodstuffs, it is possible to discern how some individuals did, or did not, consume certain foods. The availability of the mentioned food sources in Trondheim is therefore not equal to a universal consumption, but rather an overview of what could have been consumed.

3.5. The Library Site 1973-1985 & 1988-1989

In the early 1970's, the municipality of Trondheim decided to build a new public library in *Kjøpmannsgaten*, and due to archaeological potential in the area, investigations had to be done. The initial excavations at The Library Site (as it got its name from the excavations purpose) went on for 9 field seasons in the years of 1973-76, 1978-79, 1981 and 1984-85. The time schedules for excavation were changed several times, mainly due to financial problems and change of area for the new public library. The original plans stated that *Kjøpmannsgaten* 20, 22, 24 and 26 would serve as the new public library, however towards the end (decided in 1982/83), only *Kjøpmannsgaten* 20 and 22 were included to be the new public library. In the end, approximately 3250 m^2 were archaeologically investigated (Christophersen, Jondell, Marstein, Nordeide & Reed, 1988, pp. 6-8).

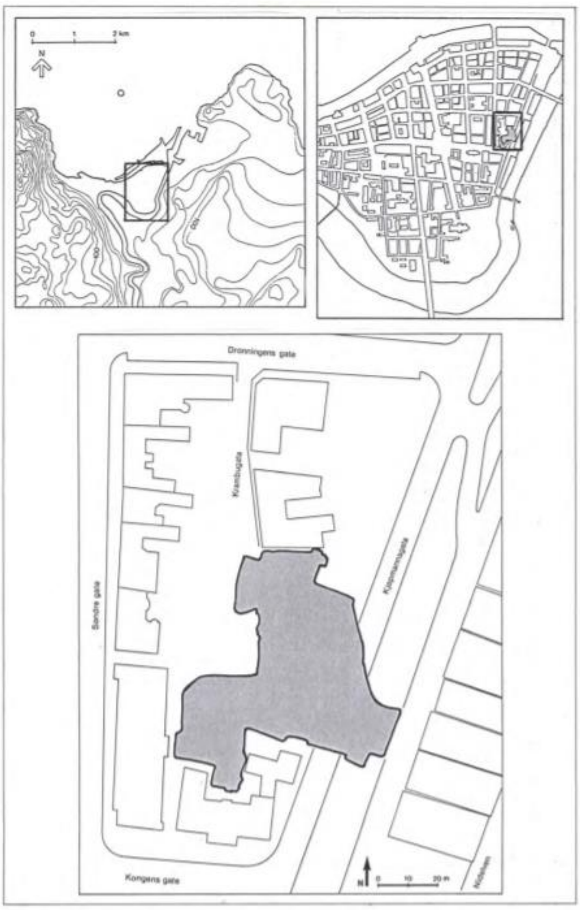

Figure 3: The Library site situated in Trondheim, as well as the total excavated area by 1985. Illustration: Christophersen, Jondell, Nordeide & Reed (1989), pp. 6.

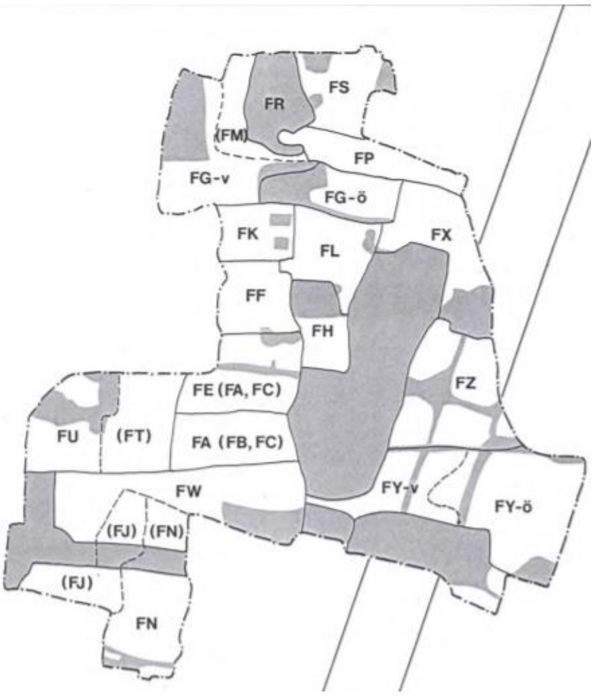

Figure 4: Subfields of The Library Site excavations, 1973-1985. Grey fields illustrate disruption of medieval layer. Illustration after Christophersen et al., 1988.

In 1984-85 parts of the cemetery belonging to what was thought to be Olav's church (*Olavskirken*) (see Christophersen & Nordeide, 1994 and Christophersen, 2020 for discussion on this) got excavated. This church was first built in the 11th-12th century as a parish church, which in the early 14th century became extended as a Franciscan monastery. However, in the 16th century the property of the monastery was gifted to a private person named Mr. Severin Pedersson, which in the 17th century was sold and became Trondheim's town hall. In 1930 the town hall was converted to a public library, as it still remains to this day (Ekroll, 1989; Christophersen, 2020).

During the excavations of the cemetery, an area of ca. 200 m^2 got excavated and 389 skeletons were disinterred. All skeletal remains were cleaned and recorded by a recording sheet, photography, and drawings (Anderson, 1986, pp. 1-2). During the excavations, the area was divided into different fields and phases. The cemetery, located in field FJ, FN, and FW, had 22 graves from phase 4-5 (AD 1075-1225), 191 from 6-7 (AD 1125-1300), and entailed 146 graves from phase 8-11 (AD 1225-1600) (Forsåker & Göthberg, 1986; Nordeide, 1988). Göthberg (1986) has placed all 389 graves (except one) into new phases based on both stratigraphy and grave goods:

Phase A (12th century, equivalent to phase 4-5): 22 individuals

Phase B (12th – 13th century, equivalent to phase 6-7): 198 individuals

Phase C (13th-17th century, equivalent to phase 8-11): 168 individuals

Preservation of the individuals varied according to the area in which they were buried, where those of best preservation were located from the middle and north of the excavated areas. These were found in organic, often waterlogged, wood chip layers. Those of poor preservation were found in the southern area, which consisted mostly of gravelly sand. All but one individual was buried with an east-west orientation, and most of the individuals of phase A and B were buried in coffins (142 in total), whereas those of phase C were not (Anderson & Göthberg, 1986).

However, after these initial excavations had taken place, and the new public library was opened, a new project emerged. The building where the public library was previously located (*Kongens gate*), needed restauration. Being near the already excavated area, the aim of these excavations was to better expose the church ruins. Thus, in 1988 and 1989 this area was excavated, with 29 graves being uncovered in 1989. All of these graves were dated to phase C: AD 1300-1550 (Ekroll, 1989, pp.7).

In total, 27 reports from the excavations at The Library Site were made, 25 of which were from the initial excavations, and two from the excavations in 1988-89. In this thesis, 30 individuals from The Library Site were chosen, all from field FN, phase A and B. The Library Site was included due to the excessive previous works (i.e., stratigraphy, dating, preliminary reports), which makes a great basis for further research. A list of the chosen individuals, their phases and additional information from the original recording sheets, is available in appendix 1.

3.6. Søndre gate 1970-1975

The first excavations of Søndre gate started in 1970 as an emergency excavation in connection with road construction. This field was named "R", and as it was an emergency excavation, as well as at the end of the season, this site was only given 5 weeks. However, as the excavation took place, several interesting finds emerged (amongst others, human remains and chips of soapstone), and it was believed that the excavation had taken place near a medieval church. It was so forth decided that the site should be expanded, and the excavation continue (Long, 1973; Long, 1976; Ramstad, 2002). In 1971 two new fields were opened (called S and T), south of field R. It was in the western part of field S that the first signs of a church ruin and cemetery were found. Furthermore, in 1972 excavations west of field S (called A) were set out (Søndre gate 4) due to building constructions of a new venue for the bank *Sparebanken*. And it was during this excavation that the whole church ruin was uncovered, as well as several more graves (Long, 1973; Long, 1976; Ramstad, 2002). In the seasons of 1971-72, about 93-100 graves were uncovered (Moen, 1971; Long, 1973). Of these graves, one third were buried in wooden coffins, most of whom were infants. There were about 4-5 children/juvenile individuals, and the rest represented adults (including young, middle, and old adults). A few of these adult individuals were buried in coffins (Moen, 1971; Long, 1974).

Field A was divided into 5 subfields: AT (southern part), AV (western part), AM (middle part), AØ (east of AM), and AS (the eastern part, east of AØ). These subfields are illustrated in figure 5. However, as all of these fields were excavated individually, they were not stratigraphically related to each other. This makes it hard to establish whether the stratigraphical layers in each field are connected to one another, and an interpretation of this stratigraphy has been difficult to establish (Ramstad, 2002, pp. 22-25). With this, the exact dating of most of the individuals are unknown, however they are interpreted to stem from between ca. AD 1100 – 1350. This is based on the establishment of the church walls which dates to between AD 1100-1150 (Christophersen, 2020, pp. 266-267), as well as ^{14}C – dating results from 10 individuals (see Ramstad, 2002 for more). In the end, after the excavations were completed in 1975 (Long, 1976, pp. 16), about 397 individuals were excavated, based on the number of available skeletal recording sheets to this day. This includes 76 individuals from subfield AM, 150 from AS, 54 from AØ, 18 from AV, 21 from AT, and 78 from field S.

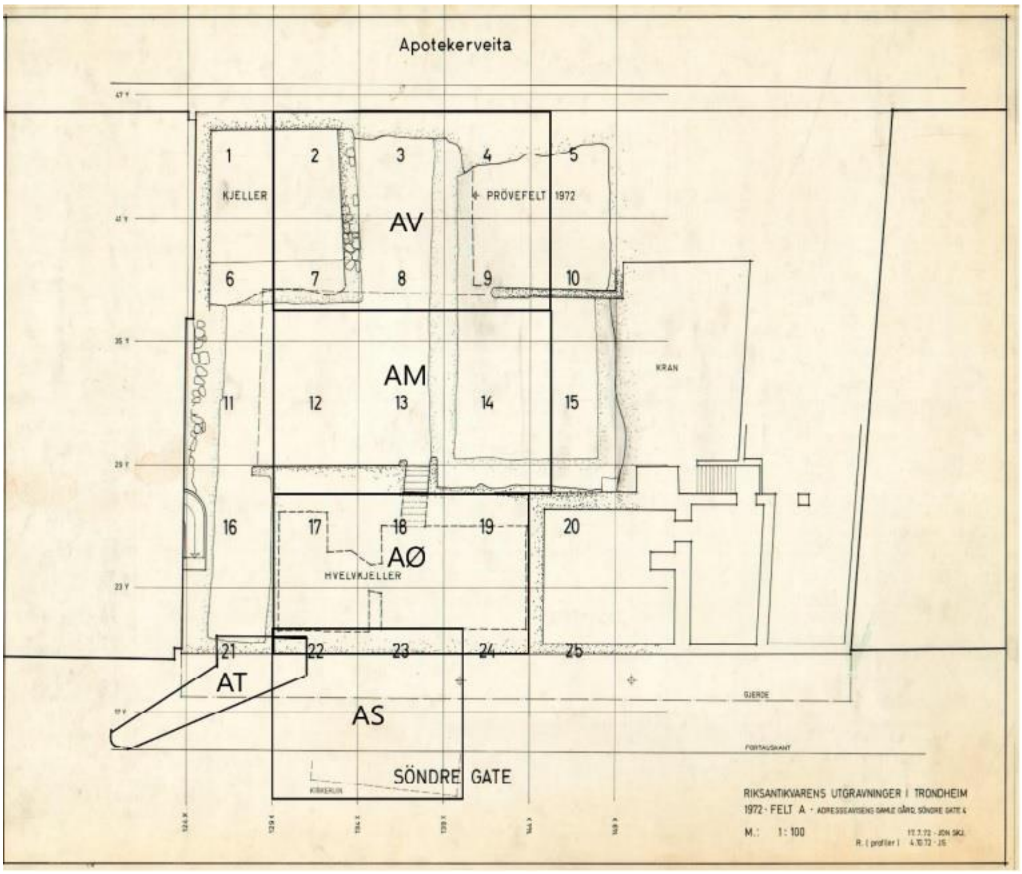

Figure 5: Field A and its subfields: AT, AS, AØ, AM & AV. Illustration: Riksantikvaren, modified by Ole Aleksander Ulvik.

Despite the excavations in field R, S, T and A, excavations were also held in Søndre gate 10 (field B), and Erling Skakkes gt. 1 (field E) (Long, 1973, pp. 30-31). All the fields are shown in figure 6.

The excavations during this period were documented by drawings, photography, and diaries, however, no official report has yet been published. Although Clifford D. Long has published several articles on these excavations (i.e., Long, 1973, 1974, 1976), and Sissel Ramstad (2002) has done extensive research of these excavations in connection to the church ruins in her *Hovedfagsoppgave* (master thesis), no official report has been issued for the excavations or the human remains. Christine Hanson (1986), however, studied 142 crania of the individuals found at Søndre gate, however excluded commingled remains (Hanson, 1986, pp. 32 and 71). Thus, due to unpublished material, 397 individuals are just an estimation done by the author herself based on the number of available recording sheets and may not represent the actual number of individuals excavated and/or buried at the cemetery. Both the lack of published material and a coalescing stratigraphy for all the fields may thus provide some sources of error. In this research 27 individuals were analyzed from Søndre gate, wherein 4 were from AM, 3 from AØ, 4 from AS, and 16 from S. A list of the chosen individuals based on the original recording sheets could be found in appendix 1.

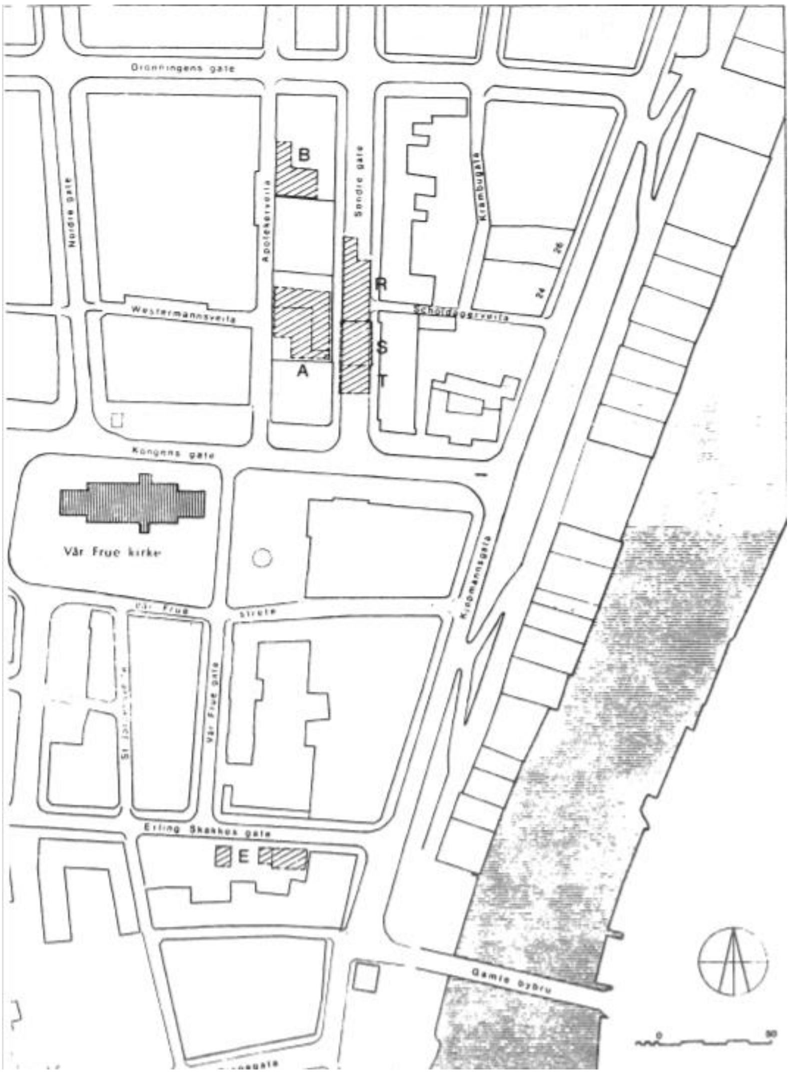

Figure 6: All the excavated fields in 1970-75 in connection with Søndre gate. Illustration: Long, C.D. 1973, pp. 31.

3.7. Summary

This chapter has sought to give a short background of the research history of osteoarchaeology in Norway and Trondheim, as well as a background of the medieval town of Trondheim, its climate and food sources. Furthermore, the background of the two sites which the individuals that were assessed stem from, were explored. As presented in this chapter, osteoarchaeology has transformed from being the responsibility of anatomists in the mid-19th- to mid-20th century, to being managed by antiquarians and archaeologists. As shown, the research on medieval human skeletal remains in Trondheim has only increased from the 1980's onwards, although few studies to this day have specialized on diet and dietary-related conditions. This thesis will therefore contributes to the continuous research of paleopathology and bioarchaeology for the medieval population of Trondheim.

Moreover, the town of Trondheim played a huge regional role in the 11th to mid-13th century as a political, religious, and economical center, and the town experienced a fluctuation and increase of people. It is so forth suggested that the town reached its populational peak by ca. AD 1300, which probably would have had its challenges (such as cramped space and more people to feed). Tree-rings and historical records tells that the town probably experienced a demographic decline already in the late 13th century, that would have lasted until the emergence of the Black Death. This was probably due to the climatic deterioration in the mid-13th century, which brought an increase of precipitation and cold temperatures. The cold climate would have led to crop failure, and over time, this could have resulted in famine, especially for those belonging to the lower socioeconomic class. The access and availability of different food sources would have changed, which could have resulted in periods of nutritional deficiencies, infectious diseases and/or general weakened health. These accentuated stressors that emerged during the 13th – 14th century, would have been in stark contrast to previous years, where the climate was seemingly more stable and warmer. Social unrest and larger socioeconomic differences are therefore not unthinkable.

The two sites where the individuals stem from is called The Library Site and Søndre gate. Excavations on the former was conducted in 1973-1985 (with an additional excavation in 1988-1989), whereas the latter was conducted in 1970-1975. Both sites entailed church ruins, which dates to the 12th-16th century. However, where the excavations of The Library Site are well documented with several publications, Søndre gate has yet to see a published report. The dating of the individuals found in the Søndre gate cemetery is therefore somewhat unknown, as well as the number of disinterred individuals. The individuals chosen from this site may therefore represent a period of 200-300 years (ca. AD 1100-1350), and thus provide some sources of error.

4. Methods

In this chapter, the chosen individuals and their representativity will be presented, followed by methods for documenting taphonomy and fragmentation, estimation of sex and age, and the observed pathologies.

4.1. The Sample and its Representativity

Due to the limitations of the thesis, 54 individuals were originally chosen to be assessed, out of 815 documented individuals from the two sites. For a complete list of the chosen individuals based on the information from the initial assessments and excavations, see appendix 1. However, during the assessments, three infants were found alongside some of the adult remains. Due to this, the total amount of assessed individuals increased to 57; 54 adults and 3 infants. 30 individuals were chosen from The Library Site, and 27 from Søndre gate, wherein 24 were adults and 3 were infants. It should be stressed that 57 individuals do not represent all buried individuals of the two sites, neither do they represent the whole medieval population of Trondheim. Therefore, emphasis must be on how these individuals only represents a chosen group based on certain criteria, as well as themselves. Future research of all the individuals from the two sites, or even a larger chosen group, could therefore present other results than shown during this research. The interpretations and conclusions found in this paper is therefore only representative for these individuals, and not all individuals buried at the two sites. Interpretating if there is a socioeconomic difference between the sites based upon this sample is therefore only an indication, and not a collective truth for all individuals of both sites.

The process of choosing individuals for the assessment were based on four criteria, as illustrated in table 1. The last criterium (nr.4) was however not applicable for the individuals from Søndre gate, as the human remains have not yet been correlated to a stratigraphic layer or been collectively dated (see chapter 3.6.). Because of this, the individuals from Søndre gate may not necessarily represent the requested period of ca. AD 1150-1250.

Table 1: Overview of the criteria made for choosing individuals.

Number	***Criterium***	***Reason for the criterium***
1	Age: ca. 18-35, young adults (YA)	To exclude diseases that may come with increased age. Children and adolescents were excluded to see possible differences between the sexes, as estimating sex morphologically in young individuals would be challenging.
2	Sex has previously been estimated.	To help establish the completeness of the individuals, and to assess differences, if there are any, between the sexes.
3	Completeness over 50% (including cranium and/or teeth)	Pathological reasons.
4	Individuals from ca. AD 1150-1250	To limit the period of when the individuals lived. With this, most of the individuals could have had experienced similar norms, laws, climate, foodstuffs and living situations.

Furthermore, another source of error was found during the review of the recording sheets for the individuals of Søndre gate, as they only included a general adult age-category, categorizing all adults as 19-50 years of age. Due to this, the sample from Søndre gate is dominated by middle adults (35-50 years), and not the desired age-category of young adults. As for The Library Site, the recording sheets showed a clear and more precise age, where almost all chosen individuals were initially placed in the category of 18-35. However, considering that the methods for estimating age has evolved throughout time, especially since the 1970-80's when the initial analyses took place, the age-categories for the assessed sample were in the end almost evenly split between young- (27 individuals) and middle adults (26 individuals). Due to this, it was decided to include middle adults to the research, rather than excluding them, in order to get a comparison of age in connection to the dietary-related conditions as well.

Moreover, the sex distribution was dominated by females (30 of 57 individuals) over males (21 of 57 individuals). As females are overrepresented, establishing differences between the sexes would be challenging and it is therefore not further discussed in detail. Another factor of representativity, is the dominance of adult individuals from The Library Site (30), compared to those of Søndre gate (24). This difference may affect the results, as it is possible that the individuals from The Library Site would dominate the occurrence and frequency of some conditions, or even provide a lower frequency as there are more assessed individuals. This must therefore also be considered when interpreting the results.

4.2. Taphonomy and Fragmentation

Taphonomy is the study of the transition of organic remains from the biosphere into the lithosphere and is concerned with how organic remains are incorporated into the geological record, and the fate of these materials after burial (Behrensmeyer & Kidwell, 1985; Lyman, 1994). In the archaeological record, skeletal remains have often experienced some postmortem damage or alterations, such as color changes, weathering, gnawing, or damage by roots (Lyman, 1994; Nikita, 2017). Such factors would affect the analysis, especially during the assessments of pathology. By example, the process called root etching, which is concerned with plant roots dissolving the mineral content of the bone, will give a result of a branching pattern on the bone surface (Lyman, 1994; Nikita, 2017). This pattern could in some cases show similarities to infections on the bone, or other pathologies (i.e., scurvy), thus considering taphonomy is a vital part of any osteoarchaeological analysis and recognizing taphonomic effects is therefore important. Furthermore, taphonomy may cause fragmentation and postmortem loss (Nikita, 2017, pp. 77-90), which would also affect the assessments of estimating age, sex, and pathology. The preservation of skeletal remains was addressed in three ways – from the total completeness of the remains, the degree of fragmentation and the degree of surface preservation. The completeness of a remain was scored according to four different stages of preservation, being: 1). between 0-25% of bones preserved, 2). between 25-50% of bones preserved, 3). between 50-75% of bones preserved, and 4). 75% or more of the bones were preserved. The fragmentation was scored as either, 1). little to no fragmentation, 2). some fragmentation, or 3). a lot of fragmentation. Lastly, the surface preservation was scored according to three degrees, being: 1). surface preservation is bad, 2.) surface preservation is adequate, and 3). surface preservation is good.

4.3. Skeletal Analyses

In this chapter the utilized methods for estimating sex, age and pathology are presented. Here, emphasis has been on os coxa (pelvis) and cranial morphology to estimate sex, and pubic symphyses (pelvis), auricular surface (pelvis), sternal rib ends (when applicable) and sternal clavicle to estimate age. The age-estimation method of cranial suture closure is not utilized due to its individual variation, history, and other implications (see Perizonius, 1984; Key, Aiello & Molleson, 1994; Hershkovitz et al., 1997). All the methods for both sex- and age-estimations are chosen to obtain a result as accurate as possible, as each method has its own success rate (Buikstra & Ubelaker, 1994, pp. 16-38). Furthermore, as archaeological remains may vary in fragmentation, some attributes may or may not be present on the bones. Applying several methods for both sex and age estimation is therefore important.

4.3.1. Sex Estimation

When estimating biological sex, features on both the os coxae and the cranium were utilized, in order to obtain more accuracy for estimating sex, as different methods may provide different results. For instance, the os coxae are more reliable than the cranium when it comes to estimating sex, due to the sexual dimorphic traits that develop during puberty, as females are biologically developed to give birth, and males are not (Buikstra & Ubelaker, 1994; Bruzek, 2002; Listi & Bassett, 2006). To estimate sex, a scoringsystem of 1-5 is used, where 1 is female, 2 is probably female, 3 is indetermined, 4 is probably male, and 5 is male.

Os Coxae Morphology

During this research the method developed by Phenice (1969) was utilized. This method focuses on three attributes of the subpubic region of the os coxae, which includes the ventral arc, subpubic concavity and ischiopubic ramus ridge (Phenice, 1969, pp. 297-301). The general difference between males and females is that the latter tends to have a more protuberant ridge of bone on the ventral arc, concave subpubic concavity, and a thin, sharp ridge on the surface of the ischiopubic ramus ridge. As for males, they tend to be the opposite, which includes a slight ridge on the ventral arc surface area, convex subpubic concavity, and a broad and flat ischiopubic ramus ridge (Phenice, 1969; Ali et al. 2020).

Furthermore, methods on the subpubic angle, the greater sciatic notch, composite arch, and the presence of the preauricular sulcus were also employed. The greater sciatic notch is determined by the width of the angle. Females tend to have a wider angle, meanwhile males tend to portray a narrower angle (Singh & Potturi, 1977; Bruzek, 2002; Listi & Bassett, 2006; Takahashi, 2006). Emphasis has also been placed on assessment of the preauricular sulcus. This attribute tends to be more present in female os coxae than in males, and if present, is located underneath the auricular surface and shown as a groove (Buikstra & Ubelaker, 1994, pp. 18). Lastly, the method of looking at the composite arch was employed. This trait evaluates the course of the auricular surface and the contour of the sciatic notch. In females, both contours appear to be sections of two circles, while in males both contours tend to appear as one circle (Bruzek, 2002, pp. 158-161). All these traits were scored separately, before an estimation of sex was given.

Sexual Dimorphic Traits of the Cranium

Although adult males tend to have more robust and larger skulls than adult females, estimating sex solely based of the cranial features may be a challenging process. Populations may vary markedly in this respect; while for some populations cranial morphology provides a reliable basis for sex determination, for others, it does not. Analyzing as many features as possible is therefore necessary to develop a correct estimation of sex in adults based on cranial features (Buikstra & Ubelaker, 1994, p.19). In this research, seven aspects of cranial morphology have been emphasized. These features include robusticity of the nuchal crest (its size and protuberance), size of the mastoid process, sharpness of the supraorbital margin, orbital shape (round vs. square shaped), prominence of glabella (the size of the projection), projection of the mental eminence, and the angle and flaring of the mandibular ramus. In all these cases, a five-point scale is used, wherein the more gracile (smaller or flatter projections) features are at the lower end of the scale, signifying female, and the larger, more protuberant, and rounded features are scored at the high end of the scale as male (Buikstra & Ubelaker, 1994, pp. 19-21).

4.3.2. Age Estimation

This chapter will present the utilized methods for estimating age at death. For adults in particular, these methods are based on research done on the pubic symphysis by Suchey-Brooks (1990), the auricular surface by Lovejoy, Meindl, Pryzbeck & Mensforth (1985) and Buckberry & Chamberlain (2002), the sternal rib end by İşcan, Loth & Wright (1984, 1985) and the sternal end of clavicles by Falys & Prangle (2015). In the case of younger adult individuals (18 to early 20's) the epiphyseal fusion was also taken into account. With infants, the long bones were measured to give an age-estimation, when applicable. For this research, individuals were placed in age-categories of young adults (18-35 years) and middle adults (35-50 years) in order to get a comparison of the frequency of dietary-related conditions according to age.

Pubic Symphysis

During the assessment, the method developed by Suchey-Brooks (1990) was utilized, where both right and left side of the pubic symphysis was scored separately. According to Suchey-Brooks (1990) there are 6 different phases, which are different between males and females. Phase 1 is characterized by a billowing surface composed of ridges and furrows, while phase 6 is characterized by ongoing depression as the rim erodes of the surface (Brooks & Suchey, 1990, pp. 232-233). The pubic symphyses are then compared to one of these phases and so forth given an age estimate.

Auricular Surface

The auricular surface is more frequently preserved in archaeological remains than the pubic symphysis, which makes it a useful feature to estimate age-at-death (Lovejoy et al., 1985, pp. 15). For estimating age based on the auricular surface, there were employed two methods; by Lovejoy et al. (1985) and Buckberry & Chamberlain (2002). According to Lovejoy et al. (1985) there are eight different phases of the auricular surface, where each side is scored separately. Phase 1, which is age 20-24, is in many ways similar to phase 1 of the pubic symphysis. Here, the auricular surface should display transverse billowing and very fine granularity. There is also no porosity or apical changes. Phase 8, on the other hand, is characterized with increased irregularity, macro- and microporosity, and there is a clear destruction of the bone. This phase is given the age of 60+ (Lovejoy et al., 1985, pp. 21-27).

As for the method by Buckberry & Chamberlain (2002), which is a revised method of Lovejoy et al. (1985), it utilizes five features for establishing age at death. These features include transverse organization, surface texture, macroporosity, microporosity, and morphological changes of the apex. Each of these features are then recorded independently and assigned a series of numerical scores corresponding to the different stages of expression. Finally, to obtain the composite score, all the individual scores of these five features are added together, and the correct age-range can then be obtained following a table made by the authors (Buckberry & Chamberlain, 2002, pp. 232-237).

Sternal Rib Ends

İşcan et al. developed a method for both males (1984) and females (1985) by looking at the sternal end of the 4th rib. This method is distributed into nine phases (0-8) which is characterized by changes noted in the form, shape, texture, and overall quality of the sternal rib. Here, phase 0 can be recognized by having a smooth, firm, flat, solid articular surface with a regular rim and rounded edges. Phase 8 on the other hand, is characterized by pitting, bony projections, and a thin and fragile rim with sharp and irregular edges (İşcan et al., 1984; İşcan et al., 1985). In males, phase 0 represents the age interval of 0-16 years of age, and for females it represents 0-14 years of age. As for phase 8, males have the age interval of 44-85 years, and females 62-90 years. This shows exactly how important it is to estimate the biological sex prior to the use of this method (İşcan et al, 1984; İşcan et al, 1985). Further research has also shown that this method is applicable to the 3rd, 4th, and 5th rib (Loth, İşcan & Scheuerman, 1994; Yoder, Ubelaker & Powell, 2001; Aktas, Koçak, Aktas & Yemisçigil, 2004).

Sternal Clavicle

In the cases of individuals with fused clavicles, the method developed by Falys & Prangle (2015) was utilized. This method focuses on the sternal end of the clavicle and its surface degeneration (Falys & Prangle, 2015, pp. 203-204), as the clavicle does not complete fusion until its mid-20's or early 30's (Stevenson, 1924; Falys & Prangle, 2015). To observe the surface degeneration, three traits are noted: surface topography, porosity, and osteophyte formation (amount of new bone formation). Each of these are then given a score between 0-6, where 0 represents that the element is not present, and 6 is characterized by complete degeneration or eburnation. Results are obtained by looking at tables of descriptive statistics for the clavicular degeneration for each sex, where the scores 3-5 include the age interval of 36-61 for males, and 35-63 for females (Falys & Prangle, 2015, pp. 204-211).

In the Case of Early Young Adults and Infants

During this research the aim was to assess young adults aged 18-35. However, determining that an individual was 18-20 at the time of death, may require other methods as well. While some could be age-estimated following the methods above, others cannot due to unfused epiphyses. For these individuals, age-estimation was obtained looking at the degree and placement of epiphyseal fusion (Stevenson, 1924, pp. 60-79), as well as the eruption of the 3rd molar. In the end, all the individual scores of ages were added together, and an age gap was obtained. In the case of infants, age was estimated by looking at the length of the long bones, when applicable (Scheuer, Musgrave & Evans, 1980; Ubelaker, 2005).

4.3.3.Pathology

During the assessment of pathology, the focus was on scurvy, osteomalacia, cribra orbitalia (CO), porotic hyperostosis (PH), and the dental pathologies: dental wear, calculus, abscess, caries, antemortem tooth loss (AMTL) and linear enamel hypoplasia (LEH). However, scurvy and osteomalacia were not distinctively and positively observed, and is thus excluded from the thesis. Other remarks of pathology were also noted, however not further explored. In this chapter the listed conditions will be described, with focus on how to spot and record these pathologies, and how they are connected to diet.

Cribra Orbitalia (CO) and Porotic Hyperostosis (PH)

Common pathologies during assessment of archaeological remains are cribra orbitalia (CO) and porotic hyperostosis (PH). While CO manifests itself as porosity on the internal surface of the orbits, PH is limited to the cranial vault. This manifestation is a result of a lack of iron in the blood stream, which then again affects the body's ability to produce hemoglobin in red blood cells. The body then compensates by producing a greater number of red blood cells, leading up to the marrow expanding and producing these lesions. This could be due to parasites, infections, malnutrition and genetic and/or chronic diseases (Stuart-Macadam, 1985, 1987, 1989; Walker, Bathurst, Richman, Gjerdrum & Andrushko, 2009; Brickley, 2018). Various degrees of CO and PH were identified and recorded after adaptations by Buikstra & Ubelaker (1994) of Stuart-Macadam (1985). The porosity was distinguished between indistinct porosity (light), coalescing pores (medium), and coalescing pores in association with expansive changes (severe). Whenever varying degrees of expression were present, the most extreme one was recorded (Stuart-Macadam, 1985, pp. 392).

Dental Wear

Dental wear has long been used to reconstruct prehistoric diet, as extreme dental wear is associated with consumption of relatively coarser foods, mastication, quality of the teeth and the use of abrading instruments. However, this reduces the location available for caries development, amongst others, and hence the frequencies of other dental pathologies must be considered due to the attrition rate (Ortner & Putschar, 1981, pp. 438-439). Dental wear is also linked to estimation of age-at-death, although not used as an age-estimation method during this research. This is due to the individual and populational variation, as cultural practices, genes, diet, and time period all affect the results (Ortner & Putschar, 1981; Maat, 2001). For recording dental wear, the method developed by Smith (1984) was utilized. This is recorded along an 8-point scale, based on the amount of exposed dentin. 1 represents no dentin exposure, while 8 appeals to a complete loss of crown, where no enamel is remaining. Each tooth is recorded separately according to the scale.

Calculus

Calculus is calcified plaque which frequently adheres to tooth surfaces, and traps food remains which could be beneficial in dietary reconstruction through microscopic and chemical analyses (Buikstra & Ubelaker, 1994; Lieverse, 1999, E.g., see Dobney & Brothwell, 1988). However, the presence and extent of the calculus formation could also contribute to reconstruct a paleodiet (Hillson, 1979, pp. 150), and is therefore one of the observed and tackled conditions in this thesis. It should be noted that the rate of calculus formation may prove some difficulty as traditions of removing and/or cleaning it may have led to postmortem loss. It is recorded as either absent, small amount, moderate amount, or large amount (Buikstra & Ubelaker, 1994, pp. 56).

Abscess

Abscess can be identified by the presence of a drainage channel through the alveolar bone (tooth sockets) from the placement of the root. This may be associated with excessive tooth wear and caries as these conditions, as well as specific dietary components, may precipitate pulpal necrosis and lead to an acute or chronic inflammatory result (Buikstra & Ubelaker, 1994; Forshaw, 2014). Abscesses are in this research recorded as present or absent.

Caries

Caries causes local destruction of dental enamel and dentine, and appears as dark eroded regions on the tooth enamel. This happens due to the shifting pH-balance of the plaque, and occurs as the plaque bacteria metabolizes carbohydrates, which then leads to production of lactic acids. This acidic environment then causes the enamel to erode (Hillson, 1979, pp. 149-150). Association between increased caries frequencies and consumption of foods rich in carbohydrates and/or sugars makes analyzing caries especially useful in dietary reconstruction (Hillson, 1979, E.g., as seen in Mant & Roberts, 2015; Koruyucu & Erdal, 2021). When recording caries, the system developed by Moore & Corbett (1971) and modified by Buikstra & Ubelaker (1994) was used. Both present or not, and location of lesion was noted accordingly: 0 = not present, 1 = occlusal surface, 2= interproximal surface (mesial and distal), 3 = smooth surface (buccal, labial and lingual), 4 = cervical caries, 5 = root caries, 6 = large caries, and 7 = noncarious pulp exposure.

Antemortem Tooth Loss (AMTL)

Antemortem tooth loss (AMTL) is loss of teeth before death occurred. This can have several causal factors, such as poor oral hygiene, caries, dental wear, deliberate removal or nutritional status (Lukacs, 1992; Lukacs, 2007). AMTL could be diagnosed from the degree of healed alveolus (tooth socket) and was recorded as either present or absent. In the case of present, the placement of the missing teeth was recorded, as well as the degree of healed alveolus according to a 4-point scale: 1) healing has just started, 2) some healing of the alveolus, 3) healing almost complete, and 4) the alveolus is completely healed.

Linear Enamel Hypoplasia (LEH)

Hypoplasia is defects in the enamel synthesis which results due to absence of factors required for enamel formation (e.g., proteins, calcium salts, water). Linear enamel hypoplasia (LEH) is a specific type of environmental hypoplasia characterized by symmetrical lines and ring-like defects involving one or several teeth (Nikiforuk & Fraser, 1981; Umapathy, Jayam, Yogish, Yogish & Bandlapalli, 2013). Enamel formation of each tooth occurs at different intervals of time and at different rates, so that a scale of age of these childhood events may be constructed for each individual (Hillson, 1979; Skinner & Goodman, 1992; Umapathy et al., 2013). The age at which the events that caused hypoplasia occurred could be estimated by measuring the distance from the occurring LEH and the cementoenamel junction ("CEJ", the border of the enamel of the crown and the cementum of the root). The measurements could then be put in an equation, to calculate the age of the LEH-occurrence (Buikstra & Ubelaker, 1994; E.g., see Dąbrowski et al., 2021). However, dental wear and populational variations could all contribute to the discrepancies in the methods of calculating LEH-occurrence (Buikstra & Ubelaker, 1994; Dąbrowski et al., 2021).

For this research LEH is recorded by which teeth it is present on, and the number of lines (hypoplasia's) on each tooth. Due to limitations in the extent of the thesis and the equipment available for this research, calculating the age of when LEH occurred, was not prioritized.

5. Results

In this chapter the results of the assessed individuals will be introduced. First, the individuals of The Library Site will be presented, then those of Søndre gate, and finally the results for both sites will be added together. Here, adults were divided into two groups: young adult (ca.18-35) and middle adult (ca. 35-50). The sexes will be divided into three groups: male (M), indetermined (I) and female (F). The groups of male and female also include those that have been established as probable male/female (M?/F?).

5.1. The Library Site

Here, all the results for the sample assessed from The Library Site will be presented, starting out with the sex and age distribution, and continuing with each pathological condition.

5.1.1. Age and Sex Distribution

In this thesis, 30 individuals were assessed from The Library Site wherein 18 were females, 10 males, and 2 were indetermined. As for age, 17 were young adults and 13 were estimated to be middle adults. The table below illustrate the sex and age distribution (table 2).

Table 2: Sex and age distribution, The Library Site. Total number of individuals = 30. M = male, M? = probably male, I = indetermined, F? = probably female, F = female. YA = young adult, MA = middle adult.

Age and sex	M	M?	I	F?	F	Total, age:
YA	4	0	2	3	8	**17**
MA	4	2	0	2	5	**13**
Total, sex:	**8**	**2**	**2**	**5**	**13**	**30**

5.1.2. Cribra Orbitalia (CO) and Porotic Hyperostosis (PH)

CO was present in 16 of the 30 assessed individuals at The Library Site (53%). In 3 individuals CO could not be observed due to missing crania or eye sockets (10%). As for sex distribution, CO dominated in females (56%), followed by males (31%). Of the age categories, it dominated in young adults (75%).

The degree of both CO and PH were divided into three categories: light, medium and severe. In CO, light dominated with 7 cases, wherein 6 were female and 1 male. Furthermore, young adults showed a more severe case of CO, with the occurrence of 5 individuals at medium and 3 at severe. The table below illustrate the distribution of both sex and age of CO and its degree (table 3), and figure 7 illustrates a severe case of CO.

Table 3: Degree of CO for each sex and age-categories, The Library Site.

Degree of CO, sex and age	*Light*	*Medium*	*Severe*
M	1	2	2
I	0	1	1
F	6	2	1
Total sex:	**7**	**5**	**4**
YA	4	5	3
MA	3	0	1
Total age:	**7**	**5**	**4**

Figure 7: Severe cribra orbitalia in the left eye socket. The otherwise smooth surface has eroded away by frequent and coalescing porosity and is displayed as a huge depression in this individual. ID: N92765, SKJ238, Field FN, The Library Site. Photo: Serina L. Griffioen

PH on the other hand, was present in 23 individuals (77%) and could not be observed in one individual (3%). Females dominated the occurrence of PH (52%), followed by males (39%). Young adults also presented the most cases of PH (61%).

The degree of PH was dominated by light (52%), where females dominated (75%). However, male individuals dominated medium cases of PH (60%). As for the age groups, young adults dominated the category of light (58%) and medium (80%), while the severe cases were split evenly between the age groups. Table 4 illustrates the degree of PH in both sex and age categories.

Table 4: Degree of PH for each sex and age-category, The Library Site.

Degree of PH, sex and age	*Light*	*Medium*	*Severe*
M	3	3	3
I	0	1	1
F	9	1	2
Total sex:	**12**	**5**	**6**
YA	7	4	3
MA	5	1	3
Total age:	**12**	**5**	**6**

5.1.3. Dental Wear

Out of the 30 individuals, the teeth of 28 individuals could be assessed for dental wear (2 individuals were not observable), wherein 17 were female (61%), 10 male (36%) and 1 was indetermined (3%). Of these, 16 were young adults (57%) and 12 were middle adults (43%). In total, 307 teeth were present for assessment, wherein 4 teeth were unable to be recognized as which tooth it was or the placement of it due to heavy wear, only parts of it present, or other damage to it. There were 823 alveoli present in the 30 individuals, making that only 37% of all possible teeth were assessed. The dental wear rates were recorded on an 8-point scale (after Smith, 1984), where 1 indicates no/little wear, and 8 indicates that no enamel is remaining (heavy wear). The table below illustrates the number of teeth present in each wear-category (table 5). In total, the wear category 4 (21%) and 5 (23%) dominates the sample of The Library Site (see figure 8).

Table 5: Number of teeth and their degree of dental wear at The Library Site (after Smith, 1984). The part to the left shows the maxillary teeth present and their degree of wear, and the part to the right shows the same for mandibular teeth. The number on top shows how many teeth there are found on the left side (sin.) for each wear-category (1-8), and the bottom one shows the number of teeth on the right side (dx.). In the end, all teeth are added up: divided between left and right, and the total number of teeth are added together (307 including 4 unknown). Max. = maxilla (upper jaw), *Mand. = Mandible* (lower jaw), *Sin (sinister) = left, Dx (dexter) = right, 1I = central Incisor, 2I = lateral incisor, C = canine, 1PM = 1st premolar, 2PM = 2nd premolar, 1M = 1st molar, 2M = 2nd molar, 3M = 3rd molar, Ukn = unknown, 1-8 = wear category, where 1 = no to little wear, and 8 = complete loss of enamel.*

Tot. Teeth FN	**Max. D. wear**	Sin. Dx. **1I**	Sin. Dx. **2I**	Sin. Dx. **C**	Sin. Dx. **1PM**	Sin. Dx. **2PM**	Sin. Dx. **1M**	Sin. Dx. **2M**	Sin. Dx. **3M**	**Mand. D. wear**	Sin. Dx. **1I**	Sin. Dx. **2I**	Sin. Dx. **C**	Sin. Dx. **1PM**	Sin. Dx. **2PM**	Sin. Dx. **1M**	Sin. Dx. **2M**	Sin. Dx. **3M**
	1			0 1					5 2	**1**	1 1		1 1				0 1	5 3
	2		0 1	1 0				4 2	2 3	**2**		0 1		0 1			1 1	4 0
	3	1 2	1 0	0 1	1 1	0 1	1 0	4 4	1 0	**3**	0 1	1 2	0 2		0 2	1 0	6 2	0 1
	4			1 1	4 4	2 0	4 4	7 9	2 0	**4**	2 0	0 1	1 0	2 1	4 3	1 3	5 2	2 0
	5	1 1		0 1	2 1	4 3	6 8	2 3		**5**	1 2			1 2	2 1	6 5	4 8	3 2
	6			1 1	1 1	3 4	5 3	2 1		**6**		0 1		1 2	0 1	6 7	1 2	2 2
	7	0 1			1 1	0 1	2 5	0 1		**7**				0 1	0 3	4 2	3 4	
	8		0 1		1 0	1 1	4 0			**8**					1 0	3 2	1 0	
	Tot. Sin.	2	1	3	10	10	22	19	10	**Tot. Sin.**	4	1	2	4	7	21	20	16
	Tot. Dx.	4	2	5	8	10	20	20	5	**Tot. Dx.**	4	5	3	7	10	19	21	8
Tot. Teeth:	**307**	**6**	**3**	**8**	**18**	**20**	**42**	**39**	**15**		**8**	**6**	**5**	**11**	**17**	**40**	**41**	**24**
Ukn:	4																	

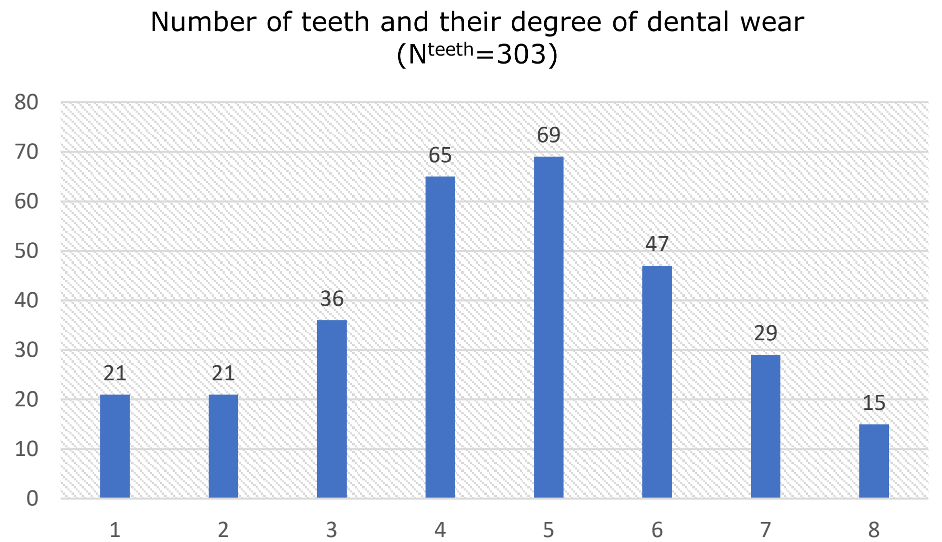

Figure 8: Number of teeth in each wear category, 1-8. N^{teeth}= number of teeth, 1-8 = wear category. Category 4 and 5 dominates the sample. 303 teeth were able to be assessed for dental wear.

Both females and young adults had a higher number of preserved teeth, as shown in table 6. Most preserved teeth were found in young adult females (41%), followed by middle adult males (18%). There were almost no differences between preserved maxillary or mandibular teeth (maxilla: 149 teeth, mandible: 157 teeth), and there were most preserved 1st and 2nd molars. Table 6 shows the distribution of preserved teeth according to sex and age.

Table 6: Distribution of number of preserved teeth between 1) the sexes, and 2) the age groups. The total number of preserved teeth for each sex/age category is shown to the right, while total preserved teeth of each tooth is shown at the bottom. 1I = central Incisor, 2I = lateral incisor, C = canine, 1PM = 1st premolar, 2PM = 2nd premolar, 1M = 1st molar, 2M = 2nd molar, 3M = 3rd molar, Ukn = unknown teeth, MA = middle adult, YA = young adult.

Total preserved teeth	***1I***	***2I***	***C***	***1PM***	***2PM***	***1M***	***2M***	***3M***	***Ukn.***	***Tot. teeth pr. sex & age***
M	5	3	6	8	15	25	29	13	0	**104**
I	2	2	3	3	3	4	4	4	0	**25**
F	7	4	4	18	19	53	47	22	4	**178**
Tot. teeth pr. Tooth sex	**14**	**9**	**13**	**29**	**37**	**82**	**80**	**39**	**4**	**307**
MA	6	1	5	11	14	28	29	13	1	**108**
YA	8	8	8	18	23	54	51	26	3	**199**
Tot. teeth pr. Tooth age	**14**	**9**	**13**	**29**	**37**	**82**	**80**	**39**	**4**	**307**

5.1.4. Calculus

Calculus was found in 19 of the 30 individuals (63%) and were not observable in 2 of them (7%) due to missing teeth. Of the 19 individuals, females dominated with 58% followed by males (37%). As for the age distribution, young adults had an occurrence of 63%, whilst it occurred in 37% of the middle adults. Calculus was divided between small-, moderate- and large amount, wherein small amount dominated the sample (58%). Females showed a more severe case of calculus formation than males. Table 7 illustrates the distribution of calculus formation between age and sex, and figure 9 shows large- and moderate amounts of calculus deposits found amongst one of the individuals.

Table 7: The distribution of the degree of calculus formation between the sexes and age groups. MA = middle adults, YA = young adults.

Degree of calculus	***Small amount***	***Moderate amount***	***Large amount***
Male, MA	2	2	0
Male, YA	2	1	0
Indetermined, YA	0	1	0
Female, MA	2	0	1
Female, YA	5	2	1
Tot:	**11**	**6**	**2**

Figure 9: Large- and moderate amounts of calculus formations on 1st and 2nd premolars, and 1st molar, right side in the mandible. ID: N94222, SKJ317, Field FN, The Library Site. Photo: Serina L. Griffioen

5.1.5. Abscess

Abscess was present in 9 of the 30 individuals (30%), wherein 7 were female (78%) and 2 were male (22%). Between the age groups, middle adults dominated the occurrence with 78%.

5.1.6. Caries

Caries was present in 5 individuals in the sample of The Library Site (17%). In 2 individuals, caries could not be observed due to missing teeth (7%). The sex distribution of caries was dominated by female (60%), followed by male and indetermined (20% each). As for age, all of the 5 individuals were young adults. Amongst these 5 individuals there were observed 16 carious lesions, wherein 10 lesions were present in the mandible. Carious lesions were mostly found at the 1st and 2nd premolars (4 lesions each). Following the recording method by Moore & Corbett (1971) modified by Buikstra & Ubelaker (1994), the dominating location was number 3 (buccal, labial, lingual). Table 8 shows the distribution of carious lesions according to this method.

Table 8: Shows number of present carious lesions found in category 0-7 after Moore & Corbett, 1971; Buikstra & Ubelaker, 1994. Number 7 indicates number of teeth with a high degree of surface wear (lead to pulp exposure) that would make the observation of carious lesions difficult/less observable. Occlusal = chewing side of premolars and molars, incisal = biting edge of incisors and canines, buccal = surface towards the cheeks, labial = surface towards the lips, mesial = between teeth; closest to the midline of the face, distal = between teeth; away from the midline of the face, lingual = surface that faces the tongue, cervical caries = caries originated at the cemento-enamel junction (ca. where the enamel and root meets), root caries = caries lesion underneath the cemento-enamel junction, on the root of the tooth.

Location of caries (Moore & Corbett, 1971; Buikstra & Ubelaker, 1994)	***Tot. number of lesions***
0 (not present)	212
1 (occlusal)	6
2 (mesial and distal)	0
3 (buccal, labial, and lingual)	10
4 (cervical caries)	0
5 (root caries)	0
6 (large caries)	0
7 (noncarious pulp exposure)	91
Total teeth with caries:	**16**

5.1.7. Antemortem Tooth Loss (AMTL)

AMTL was observed in 8 individuals (27%), and was not observable in 2 individuals (6%). Of these 8 individuals, 63% were female and 75% were middle adults. The assessments showed that 46 teeth were lost antemortem. In total, including the present assessed teeth, 353 teeth and alveoli were analyzed, making that 43% of all possible teeth in this sample were assessed. The degree of healed alveoli after loss of teeth was recorded on a 4-point scale, where 1 represent an early stage of the healing process (just started), and 4 indicates that the healing process is complete. Table 9 illustrates the distribution of AMTL and its degree of healing. In total, 59% of the teeth lost antemortem were mandibular teeth, and 44% presented degree number 3 (almost completely healed). Figure 10 shows the distribution of the degree of healed alveoli, and figure 11 shows degree 4 of healing after AMTL.

Table 9: Illustrates the number of teeth lost antemortem and the degree of healed alveoli (tooth socket). Max. = maxilla, Mand. = Mandible, Sin (sinister) = left, Dx (dexter) = right, 1I = central Incisor, 2I = lateral incisor, C = canine, 1PM = 1st premolar, 2PM = 2nd premolar, 1M = 1st molar, 2M = 2nd molar, 3M = 3rd molar, 1-4 = healing degree: *Healing degree 1 = healing has just started, 2 = some healing is present, 3 = healing is almost complete, and 4 = healing is complete.*

FN Total. AMTL	**Max. AMTL**	Sin. Dx. **1I**	Sin. Dx. **2I**	Sin. Dx. **C**	Sin. Dx. **1PM**	Sin. Dx. **2PM**	Sin. Dx. **1M**	Sin. Dx. **2M**	Sin. Dx. **3M**	**Mand. AMTL**	Sin. Dx. **1I**	Sin. Dx. **2I**	Sin. Dx. **C**	Sin. Dx. **1PM**	Sin. Dx. **2PM**	Sin. Dx. **1M**	Sin. Dx. **2M**	Sin. Dx. **3M**
	1									**1**							1 1	
	2						2 0			**2**	1 1				1 0	2 0		1 0
	3	1 1	1 1	1 1	1 1	2 1	0 1	1 1		**3**				1 0	1 0	2 2		
	4				0 1	0 1	1 0			**4**	1 0	1 0	1 0		1 1	1 2	1 1	1 2
	Tot. Sin.	1	1	1	1	2	3	1		**Tot. Sin.**	2	1	1	1	3	5	2	2
	Tot. Dx.	1	1	1	2	2	1	1		**Tot. Dx.**	1	0	0	0	1	4	2	2
Tot. Teeth:	**46**	**2**	**2**	**2**	**3**	**4**	**4**	**2**			**3**	**1**	**1**	**1**	**4**	**9**	**4**	**4**

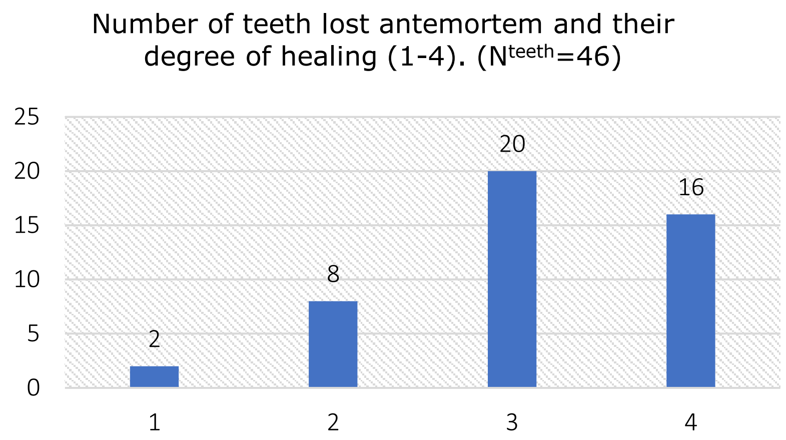

Figure 10: Number of teeth that are lost antemortem and their degree of healing (Total number = 46). Healing degree 1 = healing has just started, 2 = some healing is present, 3 = healing is almost complete, and 4 = healing is complete.

Figure 11: Antemortem tooth loss on left and right side of the mandible. The teeth lost are 2nd premolars and 1st - 3rd molars, both sides. The alveoli are completely healed. ID: N94768, SKJ332, Field FN, The Library Site. Photo: Serina L. Griffioen.

5.1.8. Linear Enamel Hypoplasia (LEH)

Of the 30 individuals assessed from The Library Site, LEH was present in 6 individuals (20%), and was not observable in 2 of them (7%). Of those with LEH present, 4 of them were male (67%), one was female, and one was indetermined. As for the age distribution, 67% were young adults. In total, 11 teeth were present with LEH, wherein most of them were maxillary teeth (64%). Each tooth present with LEH was recorded, as well as the number of linear stripes on each tooth. The table below illustrates this, first for maxillary- then mandibular teeth (table 10). In total, canines were most prone to LEH (5 teeth), and most teeth showed 2 linear stripes (see table 11).

Table 10: The presence of LEH on each tooth and the number of linear stripes, divided by maxilla and mandible.

Maxilla	***Central Incisor***	***Lateral Incisor***	***Canine***	***1st premolar***	***2nd premolar***	***1st molar***	***2nd molar***	***3rd molar***
1 stripe	2							
2 stripes			1				2	
3 stripes			2					
Total:	**2**		**3**				**2**	
Mandible	**Central Incisor**	**Lateral Incisor**	**Canine**	**1st premolar**	**2nd premolar**	**1st molar**	**2nd molar**	**3rd molar**
1 stripe		1						
2 stripes			1	1				
3 stripes			1					
Total:		**1**	**2**	**1**				
Tot. max. + mand: 11	**2**	**1**	**5**	**1**			**2**	

Table 11: Total amount of teeth with 1-3 linear stripes present.

Number of stripes	***Number of teeth***
1 stripe	3
2 stripes	5
3 stripes	3
Total:	**11**

5.1.9. Summary

Of the 30 individuals assessed from The Library Site, 18 were female, 10 were male and 2 were indetermined. 17 were estimated as young adults, and 13 as middle adults. As for pathology, CO was present in 16 individuals, while PH in 23 individuals. CO and PH dominated in females (56% CO, 52% PH) and young adults (75% CO, 61% PH). In both cases, the degree of light dominated. In total, 307 teeth were present, wherein dental wear could be assessed for 303 teeth across 28 individuals. The assessed teeth represent 37% of all possible present teeth. Dental wear rates were dominated by rate 4 and 5 (on an 8-point scale). Furthermore, calculus was found in 19 of the 30 individuals (63%). The groups female (58%) and young adult (63%) dominated the sample. Of the three categories of calculus formation, small amount dominated (58%). Abscess was present in 30% of the sample, wherein females (78%) and middle adults (78%) dominated. Caries occurred in 5 individuals and included 16 carious lesions. Most lesions were found in 1st and 2nd premolars, in the mandibular teeth (10 lesions), and at the buccal/labial/lingual aspect of the tooth. AMTL was observed in 8 individuals, wherein 63% were females. Middle adults dominated with 75% occurrence, and 59% of the teeth lost antemortem had healed alveoli at stage 3 (almost completely healed). Finally, LEH was present in 6 individuals, wherein 4 were male (67%). Young adults dominated its presence as well (67%). In total, 11 teeth were observed with LEH, where maxillary teeth, canines and 2 linear stripes dominated.

5.2. Søndre gate

Furthermore, the results obtained from the sample from Søndre gate will be presented, following the same order as above.

5.2.1. Age and Sex Distribution

Of all the individuals excavated at Søndre gate, 27 were assessed for this thesis. Of the 27 individuals, 3 were infants (0-1 years old, 11%), 1 was established as an unknown adult (4%), 10 were young adults (37%), and 13 were middle adults (48%). The individual of unknown age and sex included only one femur and two teeth. As for sex, there were 12 female individuals (44%), 11 male individuals (41%), and 4 were estimated as indetermined (15%). The table below shows the distribution of both sex and age (table 12).

Table 12: Age and sex distribution of the assessed individuals at Søndre gate. MA = middle adult, YA = young adult, ?Adult = adult of unknown age, M = male, M? = probably male, I = indetermined, F? = probably female, F = female. Total amount of individuals: 27.

Age and sex distribution	M	M?	I	F?	F	Total, age:
MA	6	2	0	2	3	**13**
YA	2	1	0	2	5	**10**
?Adult	0	0	1	0	0	**1**
Infant	0	0	3	0	0	**3**
Total, sex:	**8**	**3**	**4**	**4**	**8**	**27**

5.2.2. Cribra Orbitalia (CO) and Porotic Hyperostosis (PH)

CO was present in 10 of the 27 assessed individuals at Søndre gate (37%). In 5 individuals CO was unable to be observed, meaning that there were no eye sockets or crania to be assessed for those individuals. As for sex and age distribution, 60% were male individuals, and 60% were middle adults. When it comes to the degree of CO, the category of light dominated with 5 individuals (50%), followed by medium with 4 individuals (40%). Table 13 illustrates the distribution of the degree of CO according to sex and age.

Table 13: Distribution of the degree of CO according to sex and age.

Degree of CO, sex and age	*Light*	*Medium*	*Severe*
M	4	1	1
I	0	0	0
F	1	3	0
Total, sex	**5**	**4**	**1**
YA	2	2	0
MA	3	2	1
Total, age	**5**	**4**	**1**

PH on the other hand, was present in 16 individuals (59%). In 5 individuals PH was unobservable (19%). As for the sex distribution, 9 of the 16 individuals with PH were determined as female (56%), and 7 were male (43%). The age distribution was divided evenly; 8 individuals of each age category (50%). As for the degree of PH, the category of medium dominated, with a total presence in 8 individuals (50%). Table 14 illustrates the degree of PH according to sex and age, and figure 12 shows a severe case of PH.

Table 14: Distribution of the degree of PH according to sex and age.

Degree of PH, sex and age	*Light*	*Medium*	*Severe*
M	2	4	1
I	0	0	0
F	5	4	0
Total, sex	**7**	**8**	**1**
YA	4	3	1
MA	3	5	0
Total, age	**7**	**8**	**1**

Figure 12: Porotic hyperostosis on the occipital bone (back of the head). The lesions could be characterized by porosity and depressions on the otherwise smooth surface, and is located underneath the lambdoid suture. ID: N12143, SKJ LXVIII, Field S, Søndre gate. Photo: Serina L. Griffioen

5.2.3. Dental Wear

Of all assessed individuals from Søndre gate, 24 of them presented teeth that were able to be assessed for dental wear. Of these 24 individuals, 12 were female (50%), 11 were male (46%) and 1 was indetermined (4%). 3 individuals were not observable (11%). As for the age categories, 13 were middle adults (54%), 10 were young adults (42%), and one was unable to be given an age estimation (4%). In total, 453 teeth were present for assessment, wherein 8 teeth were unable to be recognized as which tooth it was or the placement of it (due to heavy wear, only parts of it present, or other damage to it). There were 451 teeth belonging to estimated sexes and/or age groups with present mandibles and/or maxillae, in 23 individuals (see table 15). In total, 705 tooth sockets were present (in 23 individuals), making that 64% of all possible present teeth were assessed. The wear category 5 and 6 dominated the sample of Søndre gate, with 90 teeth (20%) and 84 teeth (19%) as seen in figure 13.

Table 15: Number of teeth and their degree of dental wear (after Smith, 1984). The part to the left shows the maxillary teeth present and their degree of wear, and the part to the right shows the same for mandibular teeth. The number on top shows how many teeth there are found on the left side (sin.) for each wear-category (1-8), and the bottom one shows the number of teeth on the right side (dx.). In the end, all teeth are added up (first divided between left and right, then both are added together). Max. = maxilla, Mand. = Mandible, Sin (sinister) = left, Dx (dexter) = right, 1I = central Incisor, 2I = lateral incisor, C = canine, 1PM = 1st premolar, 2PM = 2nd premolar, 1M = 1st molar, 2M = 2nd molar, 3M = 3rd molar, Ukn = unknown, 1-8 = wear category.

Tot. teeth SØ	**Max. D. wear**	**Sin. Dx. 1I**	**Sin. Dx. 2I**	**Sin. Dx. C**	**Sin. Dx. 1PM**	**Sin. Dx. 2PM**	**Sin. Dx. 1M**	**Sin. Dx. 2M**	**Sin. Dx. 3M**	**Mand D. wear**	**Sin. Dx. 1I**	**Sin. Dx. 2I**	**Sin. Dx. C**	**Sin. Dx. 1PM**	**Sin. Dx. 2PM**	**Sin. Dx. 1M**	**Sin. Dx. 2M**	**Sin. Dx. 3M**
	1								5 5	**1**								8 7
	2		2 1	2 1				5 6	1 0	**2**	2 2	2 1	0 1				3 4	2 3
	3	0 1	1 2	1 1	4 1	3 3	1 1	0 1	0 2	**3**	1 2	1 1	3 2	2 5	2 3	0 1	3 1	3 0
	4	2 3	1 0	1 1	2 3	3 3	1 1	2 2	0 2	**4**	1 2	2 3	4 3	4 5	5 5	1 0	5 7	1 2
	5	2 3	2 2	3 4	1 0		6 4	2 1		**5**	2 3	6 4	5 6	4 6	0 4	7 6	2 2	2 1
	6	2 2	3 3	4 2	4 4	6 3	2 2	1 3		**6**	1 2	2 1	5 1	3 1	8 2	6 6	3 1	0 1
	7	1 1	2 1	1 1	2 1	2 1	3 4			**7**	1 0	0 1	1 1	1 1	1 1	4 6		0 1
	8	1 3	0 3	0 3	2 5	2 4	2 2			**8**	1 2	2 1		1 0	1 1	1 0	1 1	1 0
	Tot. Sin.	8	11	12	15	16	15	10	6	**Tot. Sin.**	9	15	18	15	17	19	17	17
8 ukn	**Tot. Dx.**	13	12	13	14	14	14	13	9	**Tot. Dx.**	13	12	14	18	16	19	16	15
Tot. Teeth	**453**	**21**	**23**	**25**	**29**	**30**	**29**	**23**	**15**		**22**	**27**	**32**	**33**	**33**	**38**	**33**	**32**

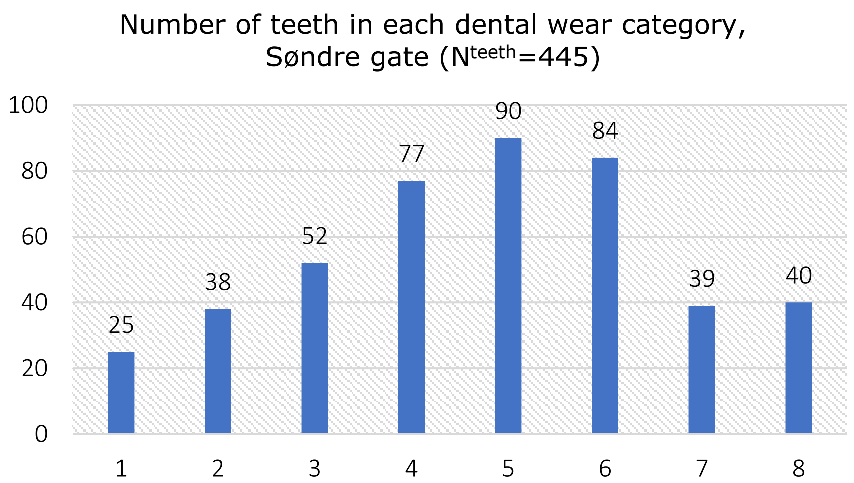

Figure 13: Number of teeth in each dental wear category of the individuals at Søndre gate. Number of teeth = 445. 1-8 = wear category, where 1 is no/little wear, and 8 is complete loss of enamel.

As for teeth preservation, females had a slightly higher number of preserved teeth than males. However, between the age groups there were almost no differences (see table 16). Most preserved teeth were found in young adult females (36%) and middle adult males (34%). There were most mandibular teeth present for assessment (55%), and most preserved 1st molars. Figure 14 shows different wear categories in one individual and thus the importance of recoding each tooth separately.

Table 16: Number of present teeth for each sex and age category. The total number of preserved teeth for each sex/age category is shown to the right, while total preserved teeth of each tooth is shown at the bottom. 1I = central Incisor, 2I = lateral incisor, C = canine, 1PM = 1st premolar, 2PM = 2nd premolar, 1M = 1st molar, 2M = 2nd molar, 3M = 3rd molar, Ukn = unknown teeth, MA = middle adult, YA = young adult.

Total preserved teeth	***1I***	***2I***	***C***	***1PM***	***2PM***	***1M***	***2M***	***3M***	***Ukn***	***Tot. teeth pr. Sex and age***
M	22	27	30	32	30	32	20	18	3	**214**
I	0	0	0	0	0	0	0	0	2	**2**
F	21	23	27	30	33	35	36	29	3	**237**
Tot. teeth pr. sex	**43**	**50**	**57**	**62**	**63**	**67**	**56**	**47**	**8**	**453**
MA	21	25	32	33	30	34	25	21	5	**226**
YA	22	25	25	29	33	33	31	26	1	**225**
Tot. teeth pr. age	**43**	**50**	**57**	**62**	**63**	**67**	**56**	**47**	**8**	**453**

Figure 14: Heavy dental wear on the right maxilla. 3rd molar represent the score 3-4, as opposed to the 2nd incisor which represents the score 7, according to the method by Smith (1984). With this, it is important to record each tooth separately. ID: N12111, N12112, SKJ XLIII, Field S, Søndre gate. Photo: Serina L. Griffioen

5.2.4. Calculus

Calculus was observed in 18 individuals (67%), wherein 11 were female (61%) and 7 were male (39%). In 3 individuals calculus was unobservable (11%). It was split evenly between the age groups (8 individuals each). As previously mentioned, calculus was divided into three categories. Here, small amount dominated the sample (61%), followed by moderate amount (28%). The table below illustrates this distribution (table 17).

Table 17: The distribution of the degree of calculus formation between the sexes and age groups. MA = middle adults, YA = young adults.

Degree of calculus pr. sex and age	*Small amount*	*Moderate amount*	*Large amount*
Male, MA	4	0	1
Male, YA	1	1	0
Female, MA	3	1	0
Female, YA	3	3	1
Tot:	**11**	**5**	**2**

5.2.5. Abscess

Abscess was observed in 9 of 27 individuals (33%). However, 4 individuals could not be assessed for the presence of abscess due to missing maxilla and/or mandible (15%). When it comes to sex and age distribution, 55% were male and 78% were middle adults. Figure 15 shows a huge perimortem abscess (still active at time of death).

Figure 15: Huge perimortem abscess at the root of the 2nd molar, right mandible. ID: N12143, SKJ LXVIII, Field S, Søndre gate. Photo: Serina L. Griffioen

5.2.6. Caries

Caries was present in 12 individuals (44%), and was not observable in 3 (11%). As for the distribution of sex and age, it was split evenly in both categories. Caries was mostly found at the 3rd molars, in both maxilla and mandible. In total there were found 35 carious lesions. Following the recording method by Moore & Corbett (1971) and modified by Buikstra & Ubelaker (1994), the dominating location was number 3 (buccal, labial, and lingual), as it was in total found 17 carious lesions (49%). Table 18 illustrates the distribution of carious lesions. Figure 16 shows a larger carious lesion found amongst the sample.

Table 18: Shows number of present carious lesions found in category 0-7 after Moore & Corbett, 1971; Buikstra & Ubelaker, 1994. Number 7 indicates number of teeth with a high degree of surface wear (lead to pulp exposure) that would make the observation of carious lesions difficult/less observable. Occlusal = chewing side of premolars and molars, incisal = biting edge of incisors and canines, buccal = surface towards the cheeks, labial = surface towards the lips, mesial = between teeth; closest to the midline of the face, distal = between teeth; away from the midline of the face, lingual = surface that faces the tongue, cervical caries = caries originated at the cemento-enamel junction (ca. where the enamel and root meets), root caries = caries lesion underneath the cemento-enamel junction, on the root of the tooth.

Location of caries (Moore & Corbett, 1971; Buikstra & Ubelaker, 1994)	***Number of lesions***
0 (not present)	282
1 (occlusal)	12
2 (mesial and distal)	4
3 (buccal, labial, and lingual)	17
4 (cervical caries)	2
5 (root caries)	0
6 (large caries)	0
7 (noncarious pulp exposure)	163
Total carious lesions:	**35**

Figure 16: Carious lesion at the distal-lingual side on the 2nd molar, right side of the maxilla. ID: N24638, SKJ14, Field AS, Søndre gate. Photo: Serina L. Griffioen

5.2.7. Antemortem Tooth Loss (AMTL)

In total, AMTL was present in 11 individuals (41%), wherein 7 were male (64%) and 4 were female (36%). AMTL could not be observed in 4 individuals (15%). 8 of the 11 individuals were middle adults (73%), and 3 were young adults (27%). In total, there were 58 teeth lost antemortem, wherein 57% were found in the maxilla. In the end, including present teeth and teeth lost antemortem, 72% of all possible teeth were assessed during this research. 28% are therefore lost postmortem. The table below illustrates the distribution of AMTL and the degree of healed alveoli (1-4). It was healing degree 3 (healing almost complete) that dominated, with 21 almost completely healed alveoli (36%). Figure 17 illustrates the distribution of the degree of healed alveoli.

Table 19: Illustrates the number of teeth lost antemortem and the degree of healed alveoli (tooth socket). Max. = maxilla, Mand. = Mandible, Sin (sinister) = left, Dx (dexter) = right, 1I = central Incisor, 2I = lateral incisor, C = canine, 1PM = 1st premolar, 2PM = 2nd premolar, 1M = 1st molar, 2M = 2nd molar, 3M = 3rd molar, 1-4 = wear category. Healing degree 1 = healing has just started, 2 = some healing is present, 3 = healing is almost complete, and 4 = healing is complete.

SØ total AMTL	**Max. AMTL**	**Sin. Dx. 1I**	**Sin. Dx. 2I**	**Sin. Dx. C**	**Sin. Dx. 1PM**	**Sin. Dx. 2PM**	**Sin. Dx. 1M**	**Sin. Dx. 2M**	**Sin. Dx. 3M**	**Mand. AMTL**	**Sin. Dx. 1I**	**Sin. Dx. 2I**	**Sin. Dx. C**	**Sin. Dx. 1PM**	**Sin. Dx. 2PM**	**Sin. Dx. 1M**	**Sin. Dx. 2M**	**Sin. Dx. 3M**
	1						0 1			**1**		1 0					1 0	
	2				0 1	0 1	1 1	1 1	0 1	**2**				1 0	1 1	2 0	2 0	1 2
	3	1 0	0 2	0 1	1 1	2 1	1 1	1 1	1 1	**3**	0 1	0 1	0 1		0 1	0 1	0 1	
	4				0 1	0 1	1 1	1 2	1 2	**4**			1 0			0 2	0 2	2 0
	Tot. Sin.	1	0	0	1	2	3	3	2	**Tot. Sin.**	0	1	1	1	1	2	3	3
	Tot. Dx.	0	2	1	3	3	4	4	4	**Tot. Dx.**	1	1	1	0	2	3	3	2
Tot. Teeth:	**58**	**1**	**2**	**1**	**4**	**5**	**7**	**7**	**6**		**1**	**2**	**2**	**1**	**3**	**5**	**6**	**5**

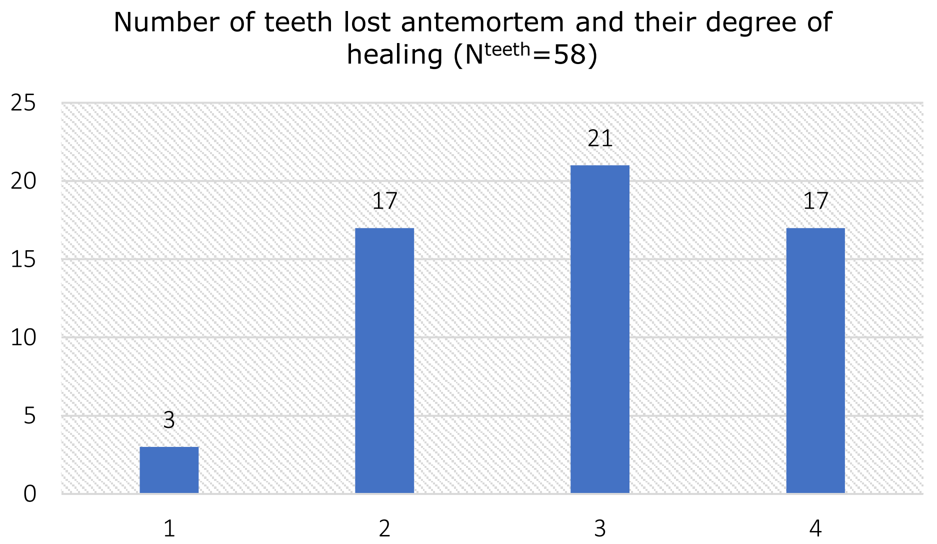

Figure 17: Number of teeth that are lost antemortem and their degree of healing. Total number = 58. Healing degree 1 = healing has just started, 2 = some healing is present, 3 = healing is almost complete, and 4 = healing is complete.

5.2.8. Linear Enamel Hypoplasia (LEH)

Of the 27 individuals assessed from Søndre gate, LEH was present in 13 of them (48%), and was not observable in 3 (11%). Of these, 54% were female and 69% were young adults. Of all the young adults assessed from Søndre gate in this thesis, 90% presented a case of LEH. In total, 58 teeth were observed with LEH, and most cases were observed in mandibles (59%). Each tooth present with LEH was recorded as well as the number of linear stripes on each tooth. The table below illustrates this, both for maxillary and mandibular teeth (table 20). In total there were observed most canines with LEH (28%). When it comes to number of linear stripes of each tooth, 2 stripes dominated the sample

(40%), followed by 1 stripe (29%), and 3 stripes (16%) (see table 21). Figure 18 shows LEH in one of the individuals from Søndre gate.

Table 20: The presence of LEH on each tooth and the number of linear stripes. In total 58 teeth were observed with LEH in Søndre gate.

Maxilla	***Central Incisor***	***Lateral Incisor***	***Canine***	***1st premolar***	***2nd premolar***	***1st molar***	***2nd molar***	***3rd molar***
1 stripe	3			2	1	3		
2 stripes	1	1	3	1				
3 stripes	1	1	1			1		1
4 stripes		1						
5 stripes								
6 stripes	1		1					
7 stripes			1					
Total:	**6**	**3**	**6**	**3**	**1**	**4**	**0**	**1**
Mandible	**Central Incisor**	**Lateral Incisor**	**Canine**	**1st premolar**	**2nd premolar**	**1st molar**	**2nd molar**	**3rd molar**
1 stripe	2	2		3			1	
2 stripes	3	5	4	4	1			
3 stripes			4					
4 stripes			1					
5 stripes	1	1						
6 stripes		1	1					
7 stripes								
Total:	**6**	**9**	**10**	**7**	**1**	**0**	**1**	
Total max. & mand.:	**12**	**12**	**16**	**10**	**2**	**4**	**1**	**1**
Tot: 58								

Table 21: Total amount of teeth with 1-7 stripes present, Søndre gate.

Number of stripes	***Number of teeth***
1 stripe	17
2 stripes	23
3 stripes	9
4 stripes	2
5 stripes	2
6 stripes	4
7 stripes	1
Tot:	**58**

Figure 18: Linear enamel hypoplasia on the left canine, 3 stripes, and 1st premolar, 1 stripe, mandible. ID: N12101, SKJ XXXV, Field S, Søndre gate. Photo: Serina L. Griffioen.

5.2.9. Summary

To summarize, there were 27 individuals assessed from Søndre gate, wherein 3 were infants, 1 was an unknown adult (both in sex and age), 10 were young adults and 13 were middle adults. 12 individuals were estimated to be female, and 11 were male. As for pathology, CO was present in 10 individuals (37%), while PH was present in 16 individuals (59%). In CO, male dominated (60%), while in PH female dominated (56%). As for age distribution, middle adults dominated in CO (60%), while PH on the other hand, was divided evenly between the age groups (50%). As for dental records, there were 453 teeth present for assessment, wherein 451 teeth had belonging maxilla and/or mandibles. Of the 23 individuals with present maxillae and/or mandibles, there were 705 present alveoli, making that 64% of all possible teeth were examined. Dental wear rates were dominated by 5 and 6 (out of 8). Abscess was observed in 9 of the individuals (33%), wherein 77% were middle adults. Males slightly dominated the occurrence of abscess (55%). Caries was present in 12 of the individuals (44%), where it was split evenly between both sexes and age-categories. The dominating location of carious lesions were on the labial, buccal and lingual aspects of the tooth (49%). As for AMTL, 58 teeth were lost antemortem, which was present in 11 individuals (41%) wherein 7 were male (64%) and 4 were female (36%). Most of the individuals were middle adults (73%), and healing degree 3 (almost completely healed) dominated (36%). LEH had a presence of 48%, wherein 54% were female and 69% were young adults. In total, the tooth that had the highest frequency of LEH was canines (28%), and it was 2 linear stripes that dominated most of the teeth (40%).

5.3. Both Sites

In the end, 57 individuals were assessed for this research. Of these, 21 were established as male (37%), wherein 16 were established as male and 5 were probably male. Furthermore, 6 individuals were indetermined (10%), and 30 individuals were female (53%), wherein 21 were established as female and 9 were probably female. As for age, 26 were established as middle adults (46%), 27 were young adults (47%), one was an adult of unknown age and sex (2%), and 3 were infants (5%).

CO was present in 26 of 49 observable individuals (53%). Of these, females dominated (50%), followed by males (42%) and lastly indetermined individuals (8%). When it comes to the age-categories, young adults dominated with 62%. Furthermore, the frequency of light CO dominated with 46% followed by medium (35%) and severe (19%). PH, on the other hand, was present in 39 of 51 observable individuals (76%), wherein 21 were female (54%), 16 male (41%) and 2 were indetermined (5%). As for age, 22 were determined as young adults (56%) and 17 were middle adults (44%). The degree of PH, was like CO, dominated by light (49%), followed by medium (33%) and severe (18%).

As for dental records, out of the 1528 possible teeth (based on present alveolus in mandibles and maxillae in 53 individuals), 758 teeth were assessed. This makes that 50% of all possible teeth were assessed for dental conditions such as wear, calculus, caries and LEH. When including teeth lost antemortem (104 teeth lost antemortem in total), it makes that 56% of all possible teeth and alveoli were assessed, and thus 44% were lost postmortem (including teeth for destructive analyses). Mandibular teeth were slightly more preserved than maxillary teeth (54%), and young adults showed a higher frequency of preserved teeth than middle adults (55%). As for dental wear, 52 individuals were able to be assessed, wherein 29 were female (56%), 21 male (40%) and 2 were indetermined (4%). Moreover, 25 individuals were estimated to be middle adults (48%), and 26 were young adults (50%). One individual was of unknown age (2%). 748 teeth were assessed for dental wear, where degree number 5 dominated the total sample (21%). This was then followed by wear degree number 4 (19%) and degree number 6 (18%). The degrees of heavier wear dominated slightly (16%) over those of less dental wear (14%).

Calculus was present in 37 of 52 observable individuals (71%), wherein 22 were female (59%), 14 were male (38%), and 1 was indetermined (3%). Of these 37 individuals, 21 were established as young adults (57%), and 16 were middle adults (43%). Calculus was divided into three degrees: small-, moderate- and large amount. Of these, small amount dominated with a presence in 22 individuals (59%), followed by moderate (30%) and large amount (11%). Moreover, abscess was present in 18 of 51 observable individuals (35%), wherein 11 were female (61%), 7 male (39%), and one was indetermined (5%). Middle adults dominated with 14 individuals (78%).

Caries was present in 17 of 52 observable individuals (33%), most of which from Søndre gate. Females dominated the frequency of caries (53%), followed by males (41%) and indetermined (6%). As for age, young adults had a frequency of 65%, and middle adults 35%. In total, there were observed 51 carious lesions, wherein 27 lesions (53%) were on the buccal/labial/lingual aspect of the tooth, and 18 lesions were on the occlusal surface (35%). Most carious lesions were observed in 3rd and 2nd molars (49% and 22%).

AMTL was present in 19 of 51 individuals (37%), wherein 10 were male (53%) and 9 were female (47%). Most of the individuals present with AMTL were established as middle adults (74%). In total 104 teeth were lost antemortem (6,8%). AMTL was recorded by the degree of healed alveoli, on a scale from 1-4 (1 being healing just started, and 4 being healing complete). Of these, healing degree 3 (almost completely healed) dominated the sample, with 41 alveoli (39%), followed by degree 4 (32%).

Finally, LEH was observed in 19 of 52 individuals (37%), most of which were from Søndre gate (68%). Of these, males dominated the sample with 10 individuals (53%), followed by females (42%), and indetermined individuals (5%). Young adults had a higher frequency of LEH (68%) than middle adults (32%). 69 teeth showed signs of LEH, wherein canines dominated (30%). The dominating number of linear stripes was 2 (41%).

6. Discussion

In this chapter the dietary-related conditions presented in chapter 5 will be discussed in relation to causal factors for the conditions. It will also be discussed whether there are any socioeconomic differences between the sites. As previously stated, scurvy and osteomalacia were not positively observed and is thus not discussed in this thesis. However, as these conditions could be challenging to diagnose in adult skeletal remains, it should be noted that several of the conditions tackled in this paper (i.e., CO, PH, AMTL) could be linked to scurvy and/or osteomalacia (Ortner & Putschar, 1981; Güllü et al., 1998; Lips, 2001; Melikian & Waldron, 2003; Maat, 2004; Brickley & Ives, 2008; Geber & Murphy, 2012; Brickley & Mays, 2019). Thus, I do not discard the possibility of it being somewhat present in the individuals, although not distinctively or positively observed based on traditional osteological analyses.

This chapter is divided into three parts. The first part tackles the conditions individually and discusses some possible causes for the shown frequency of each one. The second part debates all observed conditions in relation to each other, and what this could reveal about the diet of all the assessed individuals, as well as for the individuals of each site. Lastly, some sources of error, how individual variation affects the results, and the 'osteological paradox' will be discussed.

6.1. Each Observed Condition

Cribra Orbitalia (CO) and Porotic Hyperostosis (PH)

As previously presented, CO and PH were frequently observed both across the sites and in general, where PH clearly dominated (76%) over CO (53%). Even though the etiology of these two conditions is still debatable, the main cause is thought to be different forms of iron deficiencies (Stuart-Macadam, 1992; Walker et al., 2009; Oxenham & Cavill, 2010). These can have a number of etiologies, including hemolytic-, megaloblastic-, and iron-deficiency anemias (Oxenham & Cavill, 2010, pp. 199-200). They can be caused by both dietary and non-dietary factors, such as parasites, infections, malnutrition, or genetic diseases, and can be related to the efficiency of the absorption of iron, vitamin B9 and/or B12, as well as the availability of it (Stuart-Macadam, 1985, 1987, 1989; Walker et al., 2009; Brickley, 2018). What might have caused the high frequencies of CO

(53%) and PH (76%) observed across both sites, will be discussed with attention to the aforementioned factors.

The high frequency of CO and PH can most likely be explained by a combination of the factors mentioned above. While some individuals may have genetic and/or chronic diseases (such as Chron's disease), this was probably not the case for most of the population. The sample assessed during this research is small, which in turn decreases the possibility of assessing several individuals with such genetic/chronic diseases. Thus, the high frequency is most likely due to other causes. However, this does not exclude genetic or chronic diseases being present in some individuals. Based on this, the main source of the high frequency of CO and PH is probably caused by malnutrition and/or a combination of weakened health caused by infections and/or parasites. As for the latter, Jonas Bergman (2019) reports findings of roundworm (*ascharis sp*.), whipworm (*trichuris sp*.), and tapeworms (*Taenia saginata/solium*) from Viking- and medieval layers during excavations in Søndre gate 7-11 (2016-2017), Trondheim. Moreover, excavations at *Torvet*, Trondheim, also found parasite eggs of whipworms (*trichuris sp*.), as well as fish tapeworms (*Diphyllobothrium latum*) and lancet liver fluke (*Dicrocoelium)* from postmedieval contexts (Richer, Allison, Morandi, Adams & Allot, 2020). While tapeworms could be transferred to humans by eating uncooked pork or beef (Bergman, 2019), roundworms and whipworms are fecal-oral parasites spread through poor sanitation and fecal contamination of food and water (Mitchell, 2015; Bergman, 2019; Richer et al., 2020). These parasites are however not restricted to the poor who may not have had clean water or latrines in their houses, as even kings were infected (Mitchell, 2015, pp. 16-17). As for fish tapeworm, Mitchell (2015) discusses that the occurrence of fish tapeworms in Northern Europe and Norway (i.e., see Jones, 1979) could be explained by the increased consumption of fish, especially since it was common to eat raw, smoked, pickled, or salted fish in the medieval period in the Northern parts of Europe. The large consumption of fish and other seafoods is by example reflected in the isotopic evidence of some individuals of The Library Site, as they show an abnormal high value of $\delta^{18}N$, an isotope which generates through marine foods (Christophersen, 2020, pp. 325). Other discussed causes of the spread of parasites in Medieval Europe, is herding and living with farm animals, as well as migration (Mitchell, 2015, pp. 21-24). As previously stated, Trondheim experienced a fluctuation and migration of people, and farming of "cabbage-gardens", grains and herding animals were probably common on the peninsula of Nidarnes. All of these factors may therefore have contributed not only to the spread of parasites as Mitchell (2015) discusses, but also bacterial or viral infectious diseases. Based on this, and due to the fact that roundworms and whipworms can survive in the human intestines for a few years, parasites would probably have contributed to the lack of absorption of nutrition, which could increase the chances of getting an infection, either because of the parasite itself, or due to weakened health and immune response due to the lack of vitamins. However, since the assessed individuals probably did not host a parasite their entire life, malnutrition to some degree would most likely have been present, especially in the most severe cases of CO and PH. Moreover, a diet already low in iron and/or vitamin B9 and/or B12 would with infections or parasites have been even lower, possibly resulting in the lesions observed as CO and PH. However, which type of anemia was present? Was it due to iron, vitamin B9 or B12? Given that the availability of foodstuffs was varied (see. Chapter 3.4), the main interpretation of the shown frequency is that the diet was not plentiful enough. Foodstuffs such as dairy products (which entails vitamin B12), grains, beans, and nuts (which entails vitamin B9), and fish and meat (which contains iron) seems to have been widespread in Medieval Trondheim as illustrated in chapter 3.4., and thus a high frequency of CO and PH would seem to be caused by other factors than the variety of it. Although, the factors of genetic- and chronic diseases, infections, as well as parasites, may have contributed to the extent and severity of CO and PH as discussed, the underlying cause is most likely a less plentiful diet.

When comparing the sites, however, the results of CO and PH shows that the individuals of The Library Site had a higher frequency of CO (53%) and PH (77%) than those of Søndre gate (37% CO and 59% PH). As briefly mentioned in chapter. 3.6, the parish church belonging to The Library Site cemetery, was around AD 1300 reconstructed to a Franciscan monastery. The individuals buried in this cemetery from (especially) then on must therefore have belonged to a higher socioeconomic class than those buried in the cemetery discovered in Søndre gate. It is with this, in addition to the material culture and medieval street system (see chapter 1.1), believed that the individuals buried at The Library Site, both before and after AD 1300, belonged to a higher socioeconomic class (Personal communication, Axel Christophersen, 03.03.2022). Thus, following the hypothesis on differentiation of the socioeconomic groups stated in chapter. 1.1, it might seem strange that the individuals of a higher status would have an increased frequency of CO and PH compared to those of a lower socioeconomic class. As just discussed, the high frequency seems to stem from the food being less plentiful. Yet, in that case, why is there such a remarkable difference between the sites? Did the "upper-class" really eat less than the "lower-class"? Well, one of the reasons for this discrepancy could stem from social connotations, feelings, and view of different foodstuffs. Therefore, could some foodstuffs have been associated with poverty and peasantry? Marianne Vedeler (2017) uses three cookbooks from Denmark and Iceland, as well as zoological remains from Norwegian contexts, to discuss some of the foods the elite consumed in 14th-15th century Norway. In her study, she suggests that especially poultry and spices were seen as high-status food, as these were not available to most of the population. Furthermore, she discusses that vegetables and grains were probably common, and thus explains the lack of recipes on bread, porridge, and meals consisting of vegetables (i.e., stews). Dunne, Chapman, Blinkhorn & Evershed (2019) in their study of diet in medieval peasants at West Cotton, England, proposes that dairy products and cabbage and leek in association with stewed meats were common amongst the peasants. These products are also not as much mentioned in the recipe books of the higher social ranked population, and thus it seems that both dairy products and vegetables were consumed on a much greater level amongst the lower socioeconomic classes (Vedeler, 2017; Dunne et al., 2019). This could point to a lack of certain vitamins in the better-off individuals, especially vitamin B12 and B9. Another important point to this is that vitamin C enhances absorption of iron, and scurvy and CO/PH are therefore closely linked (Brickley & Ives, 2008, pp. 47). Thus, following the theory that vegetables and certain grains were viewed as peasant food and therefore less consumed by the better-off individuals, as shown by the examples of Vedeler (2017) and Dunne et al. (2019), the absorption of iron might not be as enhanced for the high socioeconomic individuals (however, this is also dependent of the intake of fruits and berries).

Furthermore, with Trondheim being both a religious and economic center, migration and Christianity played a central part in the establishment of the town. It is therefore not unlikely that with the migration of people and influence of Christianity and its elite, that the society and elites of Trondheim adapted the same, or at least some of, their belief systems, where for example vegetables were seen as peasant food (as seen by the example from England). Vedeler (2017) mentions how dairy products and meats were not allowed to be consumed during the Christian fasting, which could point to short periods of lack of vitamin B12 and iron. Given that the individuals at The Library Site might have belonged to a higher socioeconomic class, some of the individuals might have played a central role in the parish church, and thus adapted a strict practice of fasting (although others could also have practiced fasting!). The fasting, however, would not solely cause this high frequency, but it might have contributed to the development of anemias considering that the diet was already low in foods rich in iron/B9/B12. Moreover, another point to the discrepancy between the sites, is the later established Franciscan monastery and its monks. These monks followed a principle of begging and preaching amongst people (Halvorsen, 2022), and were therefore dependent on acquiring items through the practice of begging. As the parish church located at The Library Site got transferred to a Franciscan monastery around AD 1300 (Ekroll, 1989; Christophersen, 2020), it is not unlikely that the monks roamed the town some period before AD 1300, and hence might have been buried at the cemetery found at The Library Site. With them begging for food to survive, the occurrence of CO and PH would be affected through the economic and cultural structures of the town, its climate and food availability. As already established in chapter 3.3., the climate began to deteriorate from the mid-13th century onwards, which would affect the entire population, especially these monks practicing begging. The frequency of CO and PH at The Library Site might therefore, in some cases, be contributed by these Franciscan monks settling down in the town of Trondheim. Thus, there might be different practices when it comes to food consumption between the sites. However, other factors such as parasites, infections or the amount of food consumed could also contribute to this discrepancy. A study of food consumption in late medieval Sweden by Johan Söderberg (2015) suggests that the food consumption was less plentiful and more varied in a higher socioeconomic class. Thus, this could also have been the case of the individuals buried at The Library Site, and not necessarily negative connotations to certain foodstuffs or a more frequent practice of fasting or begging as just discussed.

With all the discussed causal factors above, the easier and dichotomous view from these results may be that the individuals from The Library Site were in fact not better-off than those of Søndre gate, and hence, the hypothesis of this divide must be reconsidered. However, another view of this high frequency at The Library Site could be that these individuals were in fact better-off, as they may have had a better individual resistance to anemias or access to health care. An example of such a view, was found amongst the ancient Maya. Due to high frequencies of porotic hyperostosis found amongst ancient Maya crania, it has previously been suggested by bioarcheologists that ancient Mayan children suffered from extremely poor nutrition (Wright & Chew, 1998, pp. 924). This was however reconsidered when forensic crania of modern adult Maya skeletons from rural Guatemala were examined. As the Guatemalan government had undertaken a national survey of metabolic diseases, Wright & Chew (1998) demonstrate that anemia was still prevalent among rural children. However, surprisingly enough, the modern crania did not show the same level of PH as those of the ancient Maya (Wright & Chew, 1998, pp. 931). The conclusion Wright & Chew (1998) made was that even though the ancient Maya had higher frequencies of PH, they were better able to grow into adulthood and develop these lesions. The modern population, on the other hand, had a much higher mortality rate than their ancestors and as a result, did not develop these lesions. Thus, one might say that the lower frequencies of PH in the modern individuals would indicate a lower prevalence of anemia, when in fact it may be that unhealthy individuals (in this case, development of PH in childhood), were more susceptible to death at an earlier age and thus did not survive to exhibit healed lesions as adults (Siek, 2013, pp. 97-98). With this example, one could also say that the assessed individuals from The Library Site were less frailty than those of Søndre gate, and therefore managed to withstand the severity and continuity of anemias, as those of Søndre gate may have died before such severe lesions were formed. Aside from this, individuals with such severe lesions must have lived with the condition for quite some time, as it could take all from one year to a decade before lesions on the skeleton starts to form (Maat, 2004; Roberts & Manchester, 2007; Siek, 2013). This could therefore suggest that the individuals from The Library Site had access to – and consumed – iron/B9/B12 -rich foods at some points. These lesions may therefore stem from either episodes of different food intake or reflect a stable and continual lack of such foodstuffs throughout their life. With this, I agree with Söderberg (2015); the food consumption seems to be more varied than plentiful in the supposedly better-off individuals from The Library Site.

As for sex and age distribution, CO and PH were both dominated by females and young adults across both sites. While the dominance of females may be explained by the overrepresentation of female individuals in the sample (30 of 57 individuals), the age distribution cannot. As much as 62% of the individuals with CO present were young adults, and 56% were young adults with PH present. As young adults had the highest frequency, as well as a more severe degree of CO and PH, this might suggest that the individuals had health-related struggles, or a diet low in certain nutrients, from early on in life. However, it should be noted that the sample of The Library Site is dominated by young adults (57%), and Søndre gate is dominated by middle adults (57%). The indication of a socioeconomic difference might therefore be contributed by this discrepancy, as CO and PH were most prevalent in young adults.

The conclusion is thus that the overall individuals did not consume enough food in terms of nutrition. The differences between the sites might suggest that there is a difference in the consumption of the variety of foods, where those of The Library Site might have viewed certain foodstuffs as peasant food, and therefore consumed less of it, or had other practices (such as fasting and begging) that would have contributed to the high frequencies of CO and PH. Furthermore, the individuals from The Library Site might have had a better individual resistance or better access to health care, creating time for these lesions to form, and hence either reflect episodic lack of these vitamins or a stable and continual lack of it. The individuals of Søndre gate might therefore not have had the same varied diet, and hence consumed more of certain foodstuffs (i.e., foods rich in vitamin B12 and B9) than those of the opposing site, making CO and PH not as prevalent. The individuals of Søndre gate might also have died before lesions observed as CO and PH got formed, which in turn could suggest that these individuals were more frailty or did not have access to health care.

Dental Wear

When it comes to dental wear, 52 individuals were assessed, with 748 teeth able to be assessed for dental wear, where the wear category of 5 dominated the total sample (21%). As for each site, the individuals of The Library Site had a slightly lower degree of wear (4 and 5) than those of Søndre gate (5 and 6). However, while the individuals assessed for wear at The Library Site is dominated by young adults (57%), Søndre gate is dominated by middle adults (57%). Due to this, the difference seen by which wear category occurs most frequently is interpreted as to be caused by the dominant age-group for each site. Furthermore, almost twice as many teeth were assessed from Søndre gate (64%), compared to The Library Site (37%). This could therefore also contribute to the discrepancy between the sites. However, the overall dominating degree of dental wear is worth noticing. Degree number 5 (of 8), which entails that at least two large dentin areas are exposed in the (pre)molars, and that the dentin is exposed with a complete enamel rim in the incisors/canines, is a general heavy degree of wear. This is a huge contrast to what one would see today, as it is according to a study conducted on 3187 Europeans dominated by no wear to early surface loss in young adults (Bartlett et al., 2013, pp. 1008-1011). According to Esclassan et al. (2015) food was the main cause of tooth wear in medieval populations across Europe (abrasive wear), as well as it increased with age. However, dental wear may also stem from tooth-to-tooth contact (attrition) or by acid (erosion) (Esclassan et al., 2015, pp. 185-191). As already established, Trondheim experienced periods of famine due to periodic crop failure and deteriorating climate in the 13th century (see chapter. 3.3), which would probably have been accentuated by the differences between the rich and the poor. Following the theory that the poor ate more grains and vegetables as presented earlier in association with CO and PH, and considering that these foodstuffs are much more abrasive than meat, one might expect that the socioeconomic groups could easily be traced based on dental wear. However, this is not the case of the assessed sample in this research. The overall wear-rate is high, suggesting that all assessed individuals had either a similar practice related to the preparing and consumption of the food (i.e., use of utensils, preserving the food etc.) and/or diet. There have been conducted a number of studies on heavy dental wear on medieval populations, several pointing out that the incomplete washed vegetables and the grinding of grains using stone tools would all have played a huge role in the extensive wear (E.g., Ganss, Klimek, & Borkowski, 2002; Esclassan et al., 2015; Richter & Eliasson, 2015; Valstrand, 2022). As for the latter, quarried quern- and millstones in Norway were mainly made of certain mica shists, a stone which easily breaks into small flakes or plates due to the high mineral content (Grenne, Heldal, Meyer & Bloxham, 2008, pp. 48-51). The extensive wear-rates seen in the sample may amongst other stem from utensils such as quernstones. Since grains would already contribute to dental wear rates, products of flour with gravel and minerals, such as bread, would increase the wear-rates even more. Similar effects could also be attributed to the consumption of meat and fish, as a normal practice to preserve these foods were air-drying (i.e., stockfish), where dust and other coarser particles could have contaminated the meat or fish during the process of preservation (Richter & Eliasson, 2015, pp. 99). Aside from coarse foods and particles of minerals, dental wear rates could also stem from acidic beverages (enamel erosion). Axel Christophersen (2020) points to that water was rarely consumed as a beverage in Trondheim, and that the everyday drinks consisted of beer, skyr, and sour milk. These products are to some extent acidic and could therefore have contributed to the erosion of the enamel on the teeth, as Richter & Eliasson (2015) points to that the consumption of acidic beverages (such as skyr and whey) in medieval Icelanders is most likely one of the reasons for their heavy wear rates. Based on this, the dental wear rates suggest that the individuals across both sites had a similar consumption of food and beverages, and/or that the practices behind preparing the food was similar. However, as only 307 teeth were assessed from The Library Site, compared to the 453 teeth from Søndre gate, it is still a possibility that there would have been a greater difference between the sites, however this is not present or shown in this sample.

In conclusion, the assessed sample showed a generally high dental wear-rate, with almost no differences between the sites. This means that all individuals had either a similar practice for preparing the food or consumed similar food and beverages.

Calculus

Calculus was present in 37 of 52 observable individuals (71%). Several factors affect the rate and extent of calculus formation, dietary patterns being one of these. In contrast to caries, which develops as the plaque bacteria produces lactate acids from metabolization of carbohydrates, calculus is developed from an alkaline environment. Diets high in protein facilitate calculus formation by increasing the alkalinity and will therefore give an indication of the content of the diet (Hillson, 1979, pp. 150-151). However, it should be emphasized that the etiology and formation process of calculus is complex, and this is a much more simplified description of the disease process. Furthermore, other factors besides diet include aspects of physiology; both genetic and environmental, cultural practices, the mineral content of the drinking water and presence of silicon (Hillson, 1979; Lieverse, 1999; Forshaw, 2014). As water was rarely consumed as a beverage (Christophersen, 2020, pp. 206), the high frequency of calculus formations suggests therefore that the individuals had a protein-rich diet. Foodstuffs rich in proteins are meat, fish, dairy products, and beans, which means that at least some of these foods were consumed regularly. There were no notable differences between the sites, suggesting that all individuals had a similar protein intake. However, which foodstuffs were preferred by each individual is unknown. While some may have consumed more fish and beans, others may have consumed more meat and cheese. As there were no major differences between the sites in calculus formation, this would be impossible to establish at this point. However, as previously mentioned, isotopic values of δ^{18}N shows that fish and other seafoods were consumed on a great level in some of the individuals from The Library Site (Christophersen, 2020, pp. 325). Thus, the present calculus formations, especially in the individuals from The Library Site, could stem from a diet rich in marine foods.

When it comes to sex and age distribution, females (59%) and young adults (57%) dominated the sample. While the dominance of females could be explained by the fact that females are overrepresented in the sample, the age dominance cannot. This may suggest that the younger individuals had a diet higher in protein or were more prone to calculus formations due to genetic conditions (i.e., production of saliva). However, as mentioned in chapter. 4.3., traditions of removing calculus may have led to postmortem loss. This might have been the case for some of the individuals assessed in this study. Small amounts of calculus dominated the overall sample (62%), which includes very small quantities and traces of calculus. In some of these cases the calculus seemed to have been previously removed, which is explained by the placement and amount of calculus, as well as a lighter membrane at the CEJ. Although taphonomy could play a role in the color scheme, it was in the cases of a visible membrane at the CEJ, as well as small traces of calculus between the teeth, concluded to stem from a previous larger calculus formation. The dominance of small amounts, as well as the frequency across the sample, would therefore be affected by this postmortem loss. Based on this, the shown difference between the age-groups would not necessarily reflect the actual calculus formation in these individuals. Another point to this difference between the age-groups is that middle adults had a higher rate of dental wear and AMTL (see chapter. 5), which would affect the frequency of other conditions, such as calculus. The high frequency of calculus in young adults may therefore also be related to the degree of dental wear and AMTL, and not necessarily reflect a difference in diet.

To conclude, based on the occurrence of calculus, it seems that all the assessed individuals had a similar type of diet, a diet high in proteins. However, which foodstuffs were consumed by each of these individuals, are unknown. It is therefore with these results concluded that all individuals had a similar diet in terms of protein intake, however the practice behind the consumption, such as individual choice, what was preferred to eat and societal norms and choices, could be different. Nonetheless, this is not possible to trace based on calculus alone. Traditions of removing calculus, which seems to be the case of some individuals assessed in this paper, makes the recording and interpretations of calculus difficult, especially considering socioeconomic differences.

Abscess

Abscess was observed in 18 of 51 individuals (35%), where females (61%) and middle adults (78%) dominated the sample. Abscesses could be associated with other dental conditions such as caries, calculus, AMTL and dental wear, as abscesses are essentially a drainage channel for infections (Buikstra & Ubelaker, 1994; Forshaw, 2014). The frequency of abscess may not provide much insight into the consumption of food but is however important when comparing to the frequency of other dental conditions. Thus, based on the frequency of abscesses, it seems that some of the individuals struggled with different dental conditions, especially the middle adults. Females also dominated the sample, yet this could be attributed to the dominating sex in the assemblage. There were no differences between the sites, even with the dominance of middle adults at Søndre gate. This may suggest that the individuals buried at each site struggled equally with infections and abscesses, however, taking the statistics of the dominance of age-categories into account, and since abscess dominates in middle adults, the Library Site would prove to have a slightly higher frequency than Søndre gate. With this, the individuals of The Library Site might have struggled more with other dental conditions such as heavier wear, more caries or calculus, than those of Søndre gate. However, this would be challenging to estimate as AMTL and teeth preservation may confound the evidence.

Caries

Caries was present in 17 of 52 individuals (33%), where most of them originate from Søndre gate (71%). This is a generally low frequency compared to the prevalence of the other conditions. However, in association with the high frequencies of calculus formations, this frequency is higher than one might expect. Manji, Fejerskov and Baelum (1989b) states in fact that a population with high frequencies of caries is likely to have less frequent calculus deposits, and vice versa. Simon Hillson (2001), however, discusses how this relationship is not a strong one, and that it does not apply on an individual level, as it is quite common to see caries and calculus development on the same tooth. With this, the frequencies of both caries and calculus are not an abnormal one. Furthermore, as mentioned in chapter 4.3., caries develops when consuming foods and drinks rich in carbohydrates and sugars, such as fruits, berries, honey, vegetables, dairy products, grains, beer, and wine. Although proteins were greatly consumed (based on the frequency of calculus), foods rich in carbohydrates have also been immensely consumed as there were in total observed 51 carious lesions in the 17 individuals. This shows that the paleodiet was somewhat varied and consisted of carbohydrates across both sites.

What is even more interesting, is that 44% of all the assessed individuals from Søndre gate presented teeth with carious lesions, compared to those of The Library Site (17%). This may suggest that there is a relationship between social status and caries in the assemblage. Other researchers have also found a similar pattern: the elite individuals may have consumed more animal protein and fewer carbohydrates, and the non-elites may have consumed more carbohydrates (Mant & Roberts, 2015, pp. 199). But what exactly may have caused the high frequencies of caries in the sample from Søndre gate? Considering the low cariogenic qualities of fresh fruit and vegetables (Rugg-Gunn & Nunn, 1999, pp. 40-41), it is unlikely that consumption of fresh fruit would have led to this disparity. Furthermore, milk and dairy products could also be considered non-cariogenic (Rugg-Gunn & Nunn, 1999, pp. 41-43), and the consumption of dairy products would with this also not cause the discrepancy. Starchy foods, on the other hand, were found to be somewhat cariogenic, and the addition of sugar in cooked starchy foods would increase the cariogenicity of it (Rugg-Gunn & Nunn, 1999, pp. 43-45). Even though the emergence of cane sugar in Europe could be seen from earlier periods (depends on geographical location), it was only generally established in Europe by the 15th to 16th century (de Lemps, 1999, pp. 383-384). It is therefore unlikely that the consumption of cane sugar would have led to the increase in carious lesions in the individuals from Søndre gate. Honey, on the other hand, which probably is just as cariogenic as refined sugar (Rugg-Gunn & Nunn, 1999, pp. 53), was both imported and exported from ca. AD 1100 in Trondheim (Christophersen, 2020, pp. 126), and could have been used both as an ingredient for sweetening and preserving foods (Allsop & Miller, 1996, pp. 516-517). Furthermore, according to some European studies, the Medieval peasant diet consisted mostly of grains and bread, which could make up as much as 70% of the total food intake on average (Cruz, Repetto, Morera & Tarli, 1993; Esclassan et.al., 2009). Considering that honey was used to sweeten food, and by taking bread as an example, the bread would be especially cariogenic as the starches already would contribute to the development of caries. Thus, following the hypothesis of the division of socioeconomic statuses between the sites, the huge contrast of carious lesions might be explained by the increased consumption of grains and honey in the individuals from Søndre gate. Apart from this, as mentioned in chapter 3.4, beer and/or wine were regularly consumed and probably available to most of the population, which could also contribute to the development of carious lesions. With this, the individuals from Søndre gate might also have consumed beer and/or wine occasionally. Based on this, the individuals of Søndre gate seems to have had a diet richer in carbohydrates than those of The Library Site. However, the frequency of caries is dependent on several other factors such as the degree of occlusal surface wear, calculus, teeth lost ante- or postmortem, age, and teeth preservation (Ortner & Putschar, 1981; Hillson, 2001; Tomczyk, Szostek, Komarnitki, Mańkowska-Pliszka & Zalewska, 2013). Thus, based on this, the large difference between the sites may also stem from the fact that almost twice as many teeth were assessed from Søndre gate, as well as that the frequency of other oral conditions might affect the presence of caries (i.e., calculus, wear and AMTL).

Lastly, the sex- and age distribution, as well as the placement of carious lesions will be discussed. Females (53%) and young adults (65%) dominated the overall sample. The dominance of females could yet again be explained by its dominance in the overall sample. The dominance of young adults, on the other hand, is most likely due to three factors: 1) more teeth were preserved in young adults, 2) dental wear rates are lower than in middle adults, making caries observable on (especially) the occlusal surface, and 3) AMTL is not as prevalent in young adults as in middle adults. As for the placement of the lesions, most were observed on the buccal/labial/lingual aspect of the tooth (53%) and in the occlusal surfaces (35%), as well as in molars. While the prevalence of caries on molars and on the occlusal surfaces are common (Moore & Corbett, 1971; Whittaker et al., 1981; Hillson, 2001; Mant & Roberts, 2015), the high prevalence on the buccal/labial/lingual aspects are not. The placement of lesions may be explained by two main causes. First, the dental wear rates were generally high, making caries either unobservable for the occlusal and mesial/distal surfaces, or that the lesions simply have eroded away along with the enamel. With this, the high frequency of carious lesions on the buccal/labial/lingual aspect of the tooth may simply be a result of that it was one of the only observable places left with enamel. Secondly, the amount - and placement of – calculus may have affected the placement of carious lesions. As previously stated, calculus was found in large deposits, and where it was recorded as "small amount", it was especially present between the teeth. The lack of a high prevalence of carious lesions in the interproximal places may therefore be explained by the presence of calculus. The presence of large calculus deposits may also lead to caries development underneath or around it (Hillson, 2001, pp. 265), which might be the case for the frequent placement of caries in the assessed sample.

To conclude, the general frequency of caries was low compared to other tackled conditions (33%), which may stem from the high frequency of calculus, dental wear and AMTL. Across the sites, there were observed major differences, as 44% of all assessed individuals from Søndre gate had caries present, while it was only present in 17% of the individuals at The Library Site. This discrepancy is interpreted to mainly come from a different diet across the sites, where those of Søndre gate probably consumed more grains, honey, beer and/or wine than those of The Library Site. Another factor is the difference in number of preserved teeth, as several of the teeth lost ante- and/or postmortem may have presented carious lesions. Both the sex and age distribution are expected of the sample, as there were more female individuals assessed, as well as the prevalence of other oral conditions in young adults being lower than in middle adults (i.e. AMTL and wear) making caries more observable. The dominant placement of carious lesions on the teeth were somewhat unexpected: even though caries most commonly develops on molars, the buccal/labial/lingual aspect is uncommon. However, this may be explained by the extensive wear rates, as well as the extensive calculus formations seen across the sample.

Antemortem Tooth Loss (AMTL)

AMTL was present in 37% of the individuals with present mandible/maxilla. John R. Lukacs (2007) puts forward four primary causal factors that contribute to AMTL: 1) variations in the dietary consistency, 2) nutritional deficiencies, 3) cultural or ritual ablation and 4) trauma. However, variations in diet may prove to be especially complex, as AMTL could result from numerous etiological pathways (Lukacs, 2007, pp.157-158). For instance, abrasive foods may cause severe attrition resulting in pulp exposure, abscesses, and eventually tooth loss (Ortner & Putschar, 1981; Lukacs & Pal, 1993). Soft foods, high in carbohydrates, may result in development of caries lesions, which could produce pulp exposure, abscesses and ultimately tooth loss (Ortner & Putschar, 1981;

Lukacs, 1992). Large calculus formations could also encourage tooth loss, as calculus formations may lead to periodontal disease and in the end, result in AMTL (Ortner & Putschar, 1981; Lukacs, 2007). Based on this, AMTL is not directly used to reconstruct paleodiets, but it could provide some insights into the general oral health, as well as data on how many teeth there could have been present with other dental conditions. In total 104 teeth were lost antemortem out of 1528 analyzed alveoli, which is equivalent to that 6,8% teeth were lost antemortem. This is a slightly higher frequency than what Allison Cairns (2015) found in the individuals from phase B at The Library Site (4,4%). The discrepancy may be explained by that the individuals from Søndre gate showed a higher frequency of AMTL (41%) than those of The Library Site (27%). This could suggest that the individuals from Søndre gate generally had worse oral health than those of The Library Site (either by for example eating more abrasive foods, foods rich in carbohydrates or having more calculus-deposits). A study by Nagaoka, Seki, Uzawa, Morita, Chocano (2021) found a correlation between caries and AMTL rates, and social status, where those of a lower-class burial experienced higher frequencies of AMTL and caries. Thus, with this, the seen AMTL frequency might suggest a social difference between the sites, and thus support the hypothesis on social differences between the two sites. However, since the sample from Søndre gate is slightly dominated by middle adults, it might contribute to the seen discrepancy, and thus provide some sources of errors in the interpretation.

As for age and sex distribution, 74% were middle adults. This is however not surprising as the frequency of AMTL tends to increase with age (i.e., Nagaoka, et al., 2021). As for sex, males slightly dominated the sample (53%) over females (47%). As this difference is by only one individual, and considering that middle adults were dominated by males, there were no notable or significant differences between the sexes. Healing degree number 3 (almost completely healed) dominated the sample, suggesting that the teeth lost antemortem were lost not too long before death occurred, as it takes approximately 12-16 weeks for the alveolar bone to heal (Lin, Pan, Salamanca, Lin, Chang, 2019, pp. 8). However, what caused the death – if it was related to the decreasing oral health or not – is unknown.

To conclude, AMTL was frequently observed across the sample, especially in middle adults. It was observed a difference between the sites, where those of Søndre gate had the highest frequency. This could suggest that the individuals of Søndre gate struggled more with other oral conditions, and thus had a worse oral health, compared to those of The Library Site. This might show a socioeconomic difference, however, as the sample from Søndre gate is dominated by middle adults, this is difficult to establish on AMTL alone. Healing degree of the alveolar bone was dominated by 3 (almost completely healed), suggesting that most teeth were lost not too long before death occurred.

Linear Enamel Hypoplasia (LEH)

As seen in chapter 5., LEH was present in 37% in the overall sample, where Søndre gate had the highest frequency (48%). In addition to this, the number of affected teeth as well as the number of linear stripes on each tooth, were higher in the Søndre gate sample than in The Library Site sample. Various stressors leading to LEH could be listed, including malnutrition, deficiency of vitamins and minerals, infectious diseases (both viral and bacterial) and environmental pollutants (e.g., heavy metals and fluoride). With this, linear enamel hypoplasia (LEH) may reflect health status, diet quality and the general conditions of childhood (Hillson, 1979; Skinner & Goodman, 1992; Buikstra & Ubelaker, 1994; Umapathy et al., 2013; Dąbrowski et al., 2021). However, there is no agreement on the interpretations of the results (Palubeckaité, Jankauskas & Boldsen, 2002, pp. 190). While some authors argue that the more severe and frequent LEH, the less favorable life conditions they had and hence they may have belonged to a lower socioeconomic group (Goodman, Armelagos & Rose, 1980; Wood, 1996; Malville, 1997), others argue that LEH could indicate better living conditions or a better individual resistance than those who had died in childhood without LEH present, as it indicates that the individual survived the childhood stress (E.g., Arcini, 1999). Concerning the two assessed samples presented in this thesis, these different views may offer two interpretations on social differences. Firstly, following the former view, the shown frequency of LEH may suggest that the individuals of Søndre gate experienced more childhood stress, and thus belonged to a lower socioeconomic group. Secondly, following the latter view, the high frequency of LEH in the Søndre gate sample may on the other hand suggest that these individuals had better living conditions and/or had a greater individual resistance than those who died in childhood without such enamel defects. However, even though the survivors of such childhood stress may be less frailty than those who died in childhood without it, this does still not denote that they were better-off than those of The Library Site. Based on how low the frequency of LEH was in the individuals from The Library Site (20%), in turn suggesting that these individuals experienced very little childhood stress compared to the other site, the interpretation is that those of Søndre gate belonged to a lower socioeconomic group. This is also supported by the number of linear stripes on each tooth, as some individuals from Søndre gate presented teeth with as much as six and seven linear stripes, while the most observed stripes on teeth from The Library Site were three. This suggests that the individuals from Søndre gate experienced childhood stress over a longer period than those of The Library Site. Based on LEH alone, it would be challenging to establish what the exact causal factors are; however, malnutrition, infections, parasites and vitamin deficiencies are plausible explanations for the shown frequency. In this case, the individuals from Søndre gate seems to have been more malnourished or experienced more infectious diseases than those of The Library Site during early childhood, which could be due to periods of deteriorating climate and famine (either due to colder temperatures, more precipitation, or a change in the distribution, availability, and economy of foodstuffs).

As for the dominant age-group and sex, the overall dominating age-group was young adults (68%). Boldsen (2007) demonstrates in his research of 583 medieval skeletons from the village of Tirup, Denmark, that the risk of dying at a younger age increases with the presence of LEH in adult individuals. Thus, this might suggest that the assessed individuals may have continued living with certain factors of stress to the day they died (to some extent), or that their immune response was weakened causing them to not withstand other diseases or health-related issues, and hence the young age-at-death (however, the death could be caused by other factors than disease). As for sex, males slightly dominated the sample (53%). Some authors discuss how there usually are no statistically significant differences between the sexes (Goodman et al., 1980; Malville, 1997; Palubeckaité et al., 2002), however this does not necessarily mean that the process behind generating LEH is the same. By example, some authors suggests that males could present more cases of LEH because of their greater biological sensitivity to stress (van Gerven, Beck & Hummert, 1990; Zhou & Corruccini, 1998), while others suggests that females could present a greater frequency of LEH due to different treatment and daughter neglect (Goodman et al., 1987; May, Goodman & Meindl, 1993). As males slightly dominates over females in the assessed sample, this suggests that it is rather due to biological sensitivity of stress, and not necessarily due to different treatment between the sexes, such as daughter neglect. However, as this dominance is by only two individuals, it would be challenging to establish if this is the case or not.

To conclude, individuals from Søndre gate had a greater frequency of LEH than those of The Library Site, suggesting that the individuals of Søndre gate experienced more childhood stress, and thus belonged to a lower socioeconomic group. Causal factors to this might be malnutrition, vitamin deficiencies, parasites, and infectious diseases, however it is challenging to establish what the exact causal factor is based on LEH alone. Young adults with LEH present dominated the sample, which would suggest that the childhood events causing LEH could have contributed to the early age-at-death. Lastly, there were no major or significant differences between the sexes. However, males slightly dominated the sample, suggesting that practices of different treatments between the sexes, such as daughter neglect, may not have been present in these individuals.

6.2. The Conditions in Relation to Each Other: Socioeconomic Differences Between the Sites?

Now that each condition has been discussed separately, what do they say about diet, food consumption and social differences when discussed in relation to each other? As mentioned throughout the previous discussion, establishing exactly what was consumed, or if there are any socioeconomic differences between the sites based on one single condition, is challenging. As one condition may suggest that there are socioeconomic differences, another may not, or even reject the previous suggestion. It would therefore be necessary to discuss the conditions in relation to each other to so forth establish whether these conditions could illuminate a socioeconomic difference or not. This chapter seeks to do this, where the food consumption for the total sample will first be discussed before a comparison of the sites will take place.

With an overall high frequency of CO and PH, heavy dental wear, and calculus formations, the diet seems to have been rich in proteins and coarse foods. However, the protein intake seems to primarily stem from marine foods (due to high isotopic values of $\delta^{18}N$ in some individuals), and not necessarily terrestrial meats. As the high frequency of calculus suggests a protein-rich diet, the frequencies of CO and PH suggests that this is not necessarily due to much (red) meats. Although CO and PH could stem from other vitamin deficiencies (B9 and B12), when including the high dental wear rates, it seems that grains and/or vegetables have been a central part of the diet. Dairy products were also probably consumed on a daily basis in terms of skyr and sour milk (Christophersen, 2020, pp. 206), which could also contribute to the high frequency of dental wear, as well as providing vitamin B12 to the diet. The prevalence of carious lesions also suggests that grains and probably honey were greatly consumed. However, due to AMTL the frequencies of these conditions may be altered, as AMTL may be a result of heavy wear, abscesses, calculus, and/or caries.

With this, it seems that the diet consisted of much marine foods, grains, honey, vegetables, and dairy products, and not as much terrestrial meats. However, considering that the individuals were able to survive this nutritional stress for a long time, and hence developing the observed lesions as CO and PH, they probably did have a more varied diet than just suggested, with the occasional consumption of meat. The zoological remains also suggests that cattle, sheep, goat, and pork were greatly consumed, thus terrestrial meats must have been ingested at some points. Therefore, it might rather be a general lack of food, and not necessarily certain types of foodstuffs. This could also be supported by the prevalence of LEH, as this suggests that several events of stress occurred during childhood in some of the individuals. If this stress was due to episodes of malnutrition, it could explain the occurrence and the degree of CO and PH, as some foodstuffs might have been consumed on-and-off. However, as previously discussed, both LEH and CO/PH could also be caused by infections, parasites, and genetic- and chronic conditions. Establishing what the exact cause is, when it is probably related to and combined with many other factors, is challenging. However, with all the presented evidence, my conclusion is that all the individuals in the sample did not consume enough food, rather than not having a diverse diet, where the consumption of marine foods, dairy products, vegetables, and grains probably dominated the diet. The lack of food could either be due to periodic famine as a result of the emergence of the LIA, the rapid populational growth, confined living arrangements, rapid and potent spread of parasites and infectious diseases, economic change, or new societal norms and laws. Either way, the overall consumption seems to have not been sufficient or plentiful enough.

As for each site, there are subtle differences, where the individuals from The Library Site have greater frequencies of anemias, and those of Søndre gate have a higher frequency of caries, AMTL and LEH. As already discussed, the high frequency of anemias in the individuals from The Library Site might suggest that they consumed less foodstuffs containing iron, B9 and/or B12, than those of Søndre gate. By looking at the prevalence of the tackled dental conditions, an interpretation of their diet, and thus what might have caused this high frequency, can be made. The individuals from The Library Site had a similar frequency of calculus as those of Søndre gate, suggesting that the diet of all individuals consisted of a lot of proteins, such as meat and fish. This is further supported by isotopic values, as previously mentioned. Furthermore, caries and AMTL were not as prevalent in the presumable high socioeconomic group, suggesting that the diet consisted of more soft foods, such as meat and dairy products, and not as much grains, honey, beer, or wine as it would seem for those of Søndre gate. However, when looking at the dental wear rates, the diet must have consisted of coarser foods and acidic beverages. Even though the dental wear rates are slightly lower in the individuals from The Library Site, this does not necessarily mean that they ate less coarser foods, as age, teeth preservation and AMTL affect these results. With this, it is reasonable to suggest that these individuals of a higher social status also consumed coarse foods such as grains, and acidic beverages such as skyr, sour milk, beer, and wine. In addition to this, the prevalence of LEH was truly low compared to those of Søndre gate. This suggests that the individuals from The Library Site did not experience a lot of childhood stress, and hence might have been less malnourished, or experienced less infections and parasites. However, the frequencies of anemias (CO and PH), as well as the degree of it, were in stark contrast to those of Søndre gate. As it could take a good amount of time to develop such lesions, it implies that these individuals were in fact experiencing a lack of certain vitamins from an early age on. However, from what the prevalence of other dietary-related conditions implies, the diet was varied in those of The Library Site. The conclusion is thus that the individuals from The Library Site did have a varied diet, but simply did not consume enough food. This could have been related to social factors such as an individual food preference, societal view of certain foodstuffs, religious practices, the availability, and economy, or it could have been related to genetic and biological ones.

Either way, the individuals from The Library Site would seem to have had a greater individual resistance (and/or have had access to health care), and would probably have been somewhat financially stable, as they were in fact able to survive and withstand the extreme forms of anemia observed. On top of this, as LEH was not as prevalent in these individuals, they seem to have not experienced several or continual episodes of childhood stress. The individuals from The Library Site seem therefore to have rather experienced a stable and continual lack of certain foodstuffs throughout (most of) their life, and not as much episodic malnourishment. These individuals might hence have been less affected by the climatic events, food-shortages, changes to the economy or societal laws.

As for those of Søndre gate, the diet seems to have been consisting of much more grains and starchy foods, as the occurrence of caries stood in stark contrast to those of The Library Site. This could so forth explain the increased frequency of AMTL, as Nagaoka et al. (2017) demonstrates that there might be a correlation between caries and AMTL and socioeconomic differences, where those of a lower class would display a higher frequency of these conditions. With this, the individuals of Søndre gate would seem to have consumed more grains and vegetables, hence agreeing with what was proposed by Vedeler (2017) and Dunne et al. (2019) for what the peasant diet consisted of. Furthermore, these individuals seem to have experienced more episodic nutritional stress (or more episodes with infectious diseases or parasites) than those of The Library Site. This is especially evident in the frequency and degree of LEH, as one third of the individuals with LEH experienced (at least) three to seven events of stress during childhood. Furthermore, such episodes of nutritional stress could also explain the lower frequencies of CO and PH, as these individuals may have died before such lesions got formed or transformed into severe degrees. With this, the individuals assessed from Søndre gate seem to have been more affected by the climatic events, food availability, confined living arrangements, economy and/or societal norms and laws. With this, it is reasonable to conclude that the individuals from The Library Site were belonging to a slightly higher socioeconomic group than those of Søndre gate.

However, it should be noted that the individuals of Søndre gate had a higher frequency of AMTL, as well as that over 150 more teeth were assessed. Thus, some of the discrepancies between the sites might be caused or affected by this. By example, most incisors and canines were lost postmortem, and since these are the teeth with the highest frequency of LEH, the results of LEH would be affected by this loss. The conclusion that the individuals from Søndre gate were of a slightly lower socioeconomic group than those of The Library Site is therefore not definite with these discrepancies, but rather points to the general tendencies seen in this study.

Table 22: Overview of the results seen in this study, and the interpretation of them.

	The Library Site	***Similarities***	***Søndre gate***
Dominating condition	CO, PH	Calculus, abscess	Dental wear, caries, AMTL, LEH
Interpretation	Individuals struggled more with anemias. The consumption might have been varied, however not sufficient or plentiful enough, causing the extreme forms of anemia observed.	Similar consumption of proteins. Also, similar oral health in terms of infections.	Coarse foodstuffs, as well as carbohydrates were consumed (i.e. grains, honey, vegetables). There might be a correlation between caries and AMTL, signifying that AMTL might be caused by increased caries rates. Individuals experienced more events of childhood stress (i.e. nutritional stress, infectious diseases/infections or parasites)

6.3. Variations Over Time, Individual Variations, and the Osteological Paradox

First and foremost, one factor that could play a central role in the interpretation of this sample, which may be one source of error, is the time period of when these individuals lived. As mentioned in chapter 3.6., the individuals from Søndre gate have not been correlated to a stratigraphic layer, causing the dating of these individuals to be unknown (except for those who have been radiocarbon dated). Due to this, the individuals assessed in this research may prove to stem from different periods of time, where some individuals may stem from a time of demographic, climatic and agricultural prosperity, and others may have experienced a decline in those areas. Following this, there might be great variations of causes affecting the frequency of the seen conditions, and tracing socioeconomic differences might happen on false pretenses. For example, it is not given that all who were buried at the cemetery of Søndre gate or The Library Site had the same social status, or that these cemeteries represented those of a lower or higher socioeconomic class throughout the centuries. It is possible that the status of the churches and its cemeteries have changed throughout time, which is by example seen at The Library Site when the parish church was transformed into a Franciscan monastery in the 14^{th} century. Besides, socioeconomic statuses are not as binary as separating between the "rich" and the "poor" or between "cemetery for the rich" and "cemetery for the poor". Both cemeteries are most likely consisting of all kinds of people, all of which could have had different social statuses or roles in their past society. In researching groups of individuals or even material culture, one could only look at the general tendencies and give an interpretation based on this tendency. With this being said, I do not intend to overlook the individual as its own person with its own identity, role, status, and reasons for contracting an illness (individual variations). Rather, I have attempted to look at the general tendencies concerning dietary-related conditions to see if this could contribute to illuminate – or refute - the already existing hypothesis on different socioeconomic structures of these two sites.

Secondly, another factor that might contribute to the interpretation and results found in this paper, is the representativity of individuals from each site. As pointed out in chapter 4.1., there were assessed more adult individuals from The Library Site than Søndre gate. This may therefore confound the previous interpretations. For example, if there were more assessed individuals from Søndre gate, the frequency of CO and PH might have been higher, which could refute previous results. The interpretations and conclusions in this thesis must therefore be taken with caution.

Furthermore, another important point to the interpretations of the presented data, is what James Wood, George Milner, Henry Harpending and Kenneth Weiss in 1992 called the osteological paradox. When studying paleopathology, there have been a tendency of having a dichotomous view of health through the interpretations for paleopathologists: healthy or unhealthy (Siek, 2013, pp. 92). However, Wood et al. (1992) raised the question of whether these interpretations were in fact true: health and sickness are inferred from bony lesions, yet these lesions are produced as an immune response and take a significant amount of time to form. If an individual contracted a disease that left no traces on the bone (e.g., acute condition), is it then reasonable to claim that these individuals were healthy? If bony lesions are present, the individual is deemed to be labeled as unhealthy at the time of death, and conversely, if it does not show any lesions, then it is labeled as healthy (Siek, 2013, pp. 92-93). And it is herein the osteological paradox lays: diseased individuals who lived long enough to manifest skeletal lesions were healthier than those who died of an illness before it could manifest in their bones (Wood et al., 1992, pp.344-356). They further put forward the paradox into an example consisting of three subgroups, all of which have the same potential of contracting a disease. Subgroup A) never contracts a disease that may lead up to death or bony lesions, subgroup B) contracts the disease, has it long enough to develop skeletal lesions, but there are few deaths. Finally, subgroup C) also experiences a disease, but experiences it more acutely, before any skeletal lesions have time to form. Within this hypothetical context, Wood et al. (1992) points to that during examinations of skeletal remains, it appears that only two subgroups exist instead of three: those with lesions and those without it. As a result, both subgroups A) and C) are assumed to consist of one healthy group, and subgroup B) is determined to be unhealthy. Skeletal formation is a slow process; and, depending on the condition, it could take anywhere from one year to a decade before notable lesions appear and become apparent (Maat, 2004; Roberts & Manchester, 2007; Siek, 2013). Thus, an individual with lesions cannot be considered unhealthy, when in life it was able to withstand and live with the disease for years. Therefore, while the absence of lesions does not necessarily denote absence of disease, the presence of one does not necessarily indicate sickness, but may on the other hand, represent a sign of health (Wood et al., 1992, pp. 352-354). One example of this, is what was presented in chapter 6.1. during the discussion of CO/PH, where the high frequencies of CO/PH could indicate that the individuals of The Library Site consumed less foods with iron/B9/B12, or it could signify that they had a greater individual resistance as they managed to withstand, survive, and live with the anemias into adulthood. Another example is what was discussed during LEH: the linear enamel hypoplasia's could indicate that the individual experienced a lot of childhood stress and therefore was sick and poor, or it could signify that the individual survived such an episode of stress and is therefore healthier or have a greater individual resistance than those who did not have such deformations in the enamel and died during childhood.

However, Wood et al. (1992) has since been criticized for their proposal of the osteological paradox, by example by Goodman (1993). Goodman (1993) believes that there is no osteological paradox simply because Wood et al. (1992) fails to consider other lines of evidence. He asserts that skeletal and dental remains provide information regarding the conditions at death as well as throughout life. He further denotes that if there are three hypothetical subgroups as Wood et al. (1992) put forward, then there would be a greater distribution of ages within the collection of "healthy" skeletons. Also, the subgroup of "unhealthy" (B) would not have any juvenile remains because although children might have contracted the illness, they would have lived into adulthood and developed the same characteristic lesions as other adults in their subgroup (Goodman, 1993, pp. 283). This exemplifies how individual variation (i.e., immune response, access to health care, genes, different forms of treatment, etc.) will play a part in whether the individual dies or lives. Cohen (1994) points to that not all deaths within a group occur to similar reasons or causes, as disease is not the only cause of death among humans. Even if an individual shows traces of great stress and disease, there is always a possibility that the individual died of something else that caused the death to occur even sooner. Based on this, it is not correct to assign the status healthy or unhealthy, as there are many factors playing its part in both the cause of death, and of how the illness was contracted or was treated. This leads to an issue of interpretation in paleopathology, as researchers are basing their diagnoses within a simple binary understanding of healthy and unhealthy (Siek, 2013, pp. 99-100). The presence or absence of skeletal formations informs the researcher of the individuals health at the time of death, but it cannot easily imply whether that individual was healthy or unhealthy throughout their life. Thus, implying whether a group of individuals belonged to a poorer or richer community based on such skeletal lesions, as this thesis has attempted to do, would be challenging, if not impossible. Several factors affect the formation of skeletal lesions, as well as there are many causal factors leading up to contracting a disease. As seen in this study, consumption of food, or a lack of certain foodstuffs, is not the only reason for developing these dietary-related conditions. How and where the food was prepared, what was available, what was preferred to eat by both a society, a group or one individual, religious practices, infections, parasites, genes, and chronic diseases all play a central part in the development of such conditions. Based on this, the data and interpretations presented here, could stem from a number of etiologies, and is thus not the only solution, interpretation or conclusion that could exist. Bioarchaeology and paleopathology is a complex study, and there is still a lot to learn about these assessed individuals (by for example doing isotopic analyses, DNA-analyses, analyses of the DNA of pathogens etc.). It is with this encouraged to do more research on both this sample, and other samples from Trondheim.

7. Conclusion

The hypothesis on how the cemeteries found at The Library Site and Søndre gate entailed two different socioeconomic groups, has been the starting point for this thesis. Is this divide evident in a small group of individuals based upon dietary-related conditions? This research has shown which dietary-related conditions are present in a small, assessed sample and what the differences between the two sites are. It has further shed some light on what might have caused the occurrence and shown differences of dietary-related conditions across the sites, and if there are any socioeconomic differences. During this study, there were assessed 57 individuals wherein 30 were from The library Site, and 27 were from Søndre gate. In the skeletal sample the conditions cribra orbitalia (CO), porotic hyperostosis (PH), dental wear, calculus, abscess, caries, antemortem tooth loss (AMTL), and linear enamel hypoplasia (LEH) were observed and further discussed.

With an overall high frequency of dental wear and calculus, it seems that the general diet consisted of much coarse foods (i.e. grains and vegetables) and proteins. With caries being present in the assemblage, the diet must also have entailed carbohydrates. However, with high frequencies of CO and PH, it seems that the diet has been lacking certain vitamins (iron/B9/B12). Considering that the individuals were able to withstand the severity of anemias, as well as what the occurrence of dental conditions denotes, the conclusion is that the overall individuals did have a varied diet, however, it was not sufficient or plentiful enough.

When it comes to socioeconomic differences between the sites, some differences were present. While the individuals from The Library Site dominates in the occurrence of CO and PH, the individuals from Søndre gate generally dominates the occurrence of the recorded dental conditions. The conclusion made from this, is that the individuals assessed from The Library Site did have a varied diet but did not consume enough food. Either way, these individuals probably had a great individual resistance, as they were able to survive the severe cases of anemia for so long. The individuals of Søndre gate, on the other hand, seems to have experienced more episodic nutritional stress, and hence they might have been more affected by the climatic events, food availability, and social and economic structures of the town. Based on this, the individuals of The Library Site are interpreted to be of a slightly higher socioeconomic class than those of Søndre gate.

However, as there were more teeth assessed from the individuals from Søndre gate, as well as they had a higher frequency of AMTL, the interpretation might happen on false pretenses. Furthermore, the two cemeteries probably entail different kinds of people, where they all had different statuses and roles in their past society. It is therefore not given that all individuals buried at one cemetery were of a high social class, and vice versa. The conclusion presented in this thesis is therefore not definite or representative for all buried individuals at these two sites, but rather an indication of a divide based upon this sample. Further research on this sample, and others, is encouraged to either refute or confirm these results.

8. References

Aktas, E.Ö., Koçak, A., Aktas, S., Yemisçigil, A. (2004). Intercostal Variation for Age Estimation – Are the Standards for the Right 4th Rib Applicable for Other Ribs? *Collegium Antropologicum, 28(2),* 267-272. From https://pubmed.ncbi.nlm.nih.gov/15571100/

Ali, S.H.M., Omar, N., Shafie, M.S., Ismail, N.A.N., Hadi, H., Nor, F.M. (2020). Sex estimation using subpubic angle from reconstructed three-dimensional computed tomography pelvic model in a contemporary Malaysian population. *Anatomy and Cell Biology, 53(1)*, 27-35. https://doi.org/10.5115/acb.19.135

Allsop, K. A. & Miller, J. B. (1996). Honey revisited: a reappraisal of honey in pre-industrial diets. *British Journal of Nutrition, 75*(4), pp. 513-520. https://doi.org/10.1079/BJN19960155

Anderson, T. (1986). The Churchyard on the Folkebibliotekstomt (Library Site), Trondheim: An Interim Osteological Report. In T. Anderson & H. Göthberg (Eds.), *Olavskirkens kirkegård. Humanosteologisk analyse og faseinndeling*. Fortiden i Trondheim bygrunn: Folkebibliotekstomten. Meddelelser nr. 2.

Anderson, T. & Göthberg, H. (1986). *Olavskirkens kirkegård. Humanosteologisk analyse og faseinndeling*. Fortiden i Trondheim bygrunn: Folkebibliotekstomten. Meddelelser nr. 2.

Arcini K. (1999). *Health and disease in early Lund. Osteo-pathologic studies of 3, 305 individuals buried in the first cemetery area of Lund 990-1536* (PhD). Lund: Medical Faculty Lund University.

Bartlett, D. W., Lussi, A., West, N. X., Bouchard, P., Sanz, M., & Bourgeois, D. (2013). Prevalence of tooth wear on buccal and lingual surfaces and possible risk factors in young European adults. *Journal of Dentistry, 41 (11),* pp. 1007-1013. https://doi.org/10.1016/j.jdent.2013.08.018

Behrensmeyer, A. K., & Kidwell, S. M. (1985). Taphonomy's Contributions to Paleobiology. *Paleobiology*, *11*(1), 105–119. http://www.jstor.org/stable/2400427

Bergman, J. (2019). Arkeoparasitologisk rapport, Söndre gate, Trondheim. Rapport for NIKU. Arkeologerna SHM. In: I. Sæhle, A. Petersén, P.N. Wood, K. Brink, N.E. Valstrand & K. Lorvik (2021). *Arkeologiske undersøkelser i Søndre gate 7-11, Peter Egges plass, Krambugata 2-4 m.fl., Trondheim, Trøndelag (TA 2016/21, TA 2017/03): Landskapsutvikling, tidlig urban aktivitet og middelaldersk kirkested* (NIKU, rapport nr. 97). From https://niku.brage.unit.no/niku-xmlui/handle/11250/2763893

Beyer-Olsen, E. M. S. (1989). Premaxillary hyperdontia in medieval Norwegians: a radiographic study. *Dentomaxillofacial Radiology, 18(4),* 177-179. 10.1259/dmfr.18.4.2701174

Beyer-Olsen, E. M. S., & Risnes, S. (1994). Radiographic Analysis of Dental Development used in Age Determination of Infant and Juvenile Skulls from a Medieval Archaeological Site in Norway. *International Journal of Osteoarchaeology, 4(4),* 299-303. https://doi.org/10.1002/oa.1390040405

Bjerck, L. B. & Hansson, K. (1988). *Fra åkerlapp til Palmehave. Rapport fra utgravningene i Hotell Britannias Bakgård 1986.* Arkeologiske undersøkelser i Trondheim nr. 1. Riksantikvaren, utgravningskontoret for Trondheim. Trondheim 1988.

Boldsen, J.L. (2007). Early childhood stress and adult age mortality—A study of dental enamel hypoplasia in the medieval Danish village of Tirup. *American Journal of Physical Anthropology, 132,* pp. 59-66. https://doi.org/10.1002/ajpa.20467

Bourdieu, P. (1984). *Distinction: A social critique of the judgment of taste.* Cambridge, MA: Harvard University Press.

Brickley, M.B. (2018). *Cribra orbitalia* and porotic hyperostosis: A biological approach to diagnosis. *American Journal of Physical Anthropol*ogy, *167(4),* 896– 902. https://doi.org/10.1002/ajpa.23701

Brickley, M.B. & Ives, R. (2008). The Bioarchaeology of Metabolic Bone Disease (1.ed). Hungary: Academic Press.

Brickley, M. B. & Mays, S. (2019). Chapter 15: Metabolic Disease. In Jane. E. Buikstra (ed.), *Ortner's Identification of Pathological Conditions in Human Skeletal Remains* (3rd edition, pp. 531-562). London: Academic Press.

Brooks, S. & Suchey, J.M. (1990). Skeletal age determination based on the os pubis: A comparison of the Acsádi-Nemeskéri and Suchey-Brooks methods. *Human Evolution, 5,* 227-238. https://doi.org/10.1007/BF02437238

Bruzek, J. (2002). A Method for Visual Determination of Sex , Using the Human Hip Bone. *American Journal of Physical Anthropology, 117,* 157-168. https://doi.org/10.1002/ajpa.10012

Bryson, B. (1996). Anything But Heavy Metal: Symbolic Exclusion and Musical Dislikes. American sociological review, 61(5), 884-899. https://www.jstor.org/stable/2096459

Buckberry, J. & Chamberlain, A. (2002). Age estimation from the auricular surface of the ilium: A revised method. *American Journal of Physical Anthropology, 119(3),* 231-239. https://doi.org/10.1002/ajpa.10130

Buikstra, J.E. & Ubelaker, D.H. (1994). Standards for Data Collection from Human Skeletal Remains. Research series no. 44 (25-63). Fayetteville, Ark: Arkansas Archeological Survey.

Cadamarteri, J.P., McLees, C., Petersén, A., & Reed, I. (2020). Nidarneset før Nidaros: Trondheims landskaps- og bosetningshistorie i perioden 500 f.Kr.-1000 e.Kr. *Primitive Tider, 22,* 51-73. https://doi.org/10.5617/pt.8394

Cairns, A, M. (2015). *Health in medieval and early modern Norway: A comparative analysis of the impact of social, economic and environmental change on skeletal remains* (PhD, The Australian National University). From https://openresearchrepository.anu.edu.au/handle/1885/111076

Christophersen, A. (2020). *Under Trondheim: Fortellinger fra bygrunnen*. Trondheim: Museumsforlaget.

Christophersen, A & Nordeide, S. W. (1994). *Kaupangen ved Nidelva: 1000 års byhistorie belyst gjennom de arkeologiske undersøkelsene på Folkebibliotekstomten i Trondheim 1973- 1985*. Oslo: Riksantikvaren.

Christophersen, A., Jondell, E., Nordeide S.W. & Reed, I.W. (1989). *Excavation, chronology and settlement development*. Fortiden i Trondheim bygrunn: Folkebibliotekstomten. Meddelelser nr. 17.

Christophersen, A., Jondell, E., Marstein, O., Nordeide, S. W. & Reed, I. W. (1988). *Utgraving, kronologi og bebyggelsesutvikling.* Fortiden i Trondheim bygrunn: Folkebibliotekstomten. Meddelelser;13, del 1.

Cohen, M. N. (1994). The Osteological Paradox Reconsidered. *Current Anthropology, 35*(5), pp. 629-631. From https://www.journals.uchicago.edu/doi/epdf/10.1086/204323

Cruz, T. C., Repetto, E., Morera, A. M., Tarli, S. M. B. (1993). Sampling bias in studies of dentoalveolar pathology in past human populations. Human Evolution, 8, pp. 101-110. https://doi.org/10.1007/BF02436609

Dąbrowski, P., Kulus, M.J., Furmanek, M., Paulsen, F., Grzelak, J. & Domagała, Z. (2021) Estimation of age at onset of linear enamel hypoplasia. New calculation tool, description and comparison of current methods. *Journal of Anatomy*, *239 (4),* 920– 931. https://doi.org/10.1111/joa.13462

Dobney, K. & Brothwell, D. (1988). A scanning electron microscope study of archaeological dental calculus. In Sandra L. Olsen (Ed.), *Scanning electron microscopy in archaeology* (International series 452, pp.372-385). Oxford: B.A.R. publishing

Dunne, J., Chapman, A., Blinkhorn, P., Evershed, R. P. (2019). Reconciling organic residue analysis, faunal, archaeobotanical and historical records: Diet and the medieval peasant at West Cotton, Raunds, Northamptonshire. *Journal of Archaeological Science, 107,* pp. 58-70. https://doi.org/10.1016/j.jas.2019.04.004

Dybdahl, A. (2010). Klima og demografiske kriser i Norge i middelalder og tidlig nytid. *Historisk Tidsskrift (Norge), 89(2)*, 183-222. https://doi.org/10.18261/ISSN1504-2944-2010-02-03

Ekroll, Ø. (1989). *Olavskyrkja: 8 fragment blir monument*. Arkeologiske undersøkelser i Trondheim nr. 3. Riksantikvaren, utgravningskontoret for Trondheim. Trondheim 1989.

Erickson, B. H. (1996). Culture, Class and Connections. American Journal of Sociology, 102(1), 217-251. https://www.jstor.org/stable/2782191

Esclassan, R., Grimoud, A. M., Ruas, M. P., Donat, R., Sevin, A., Astie, F., Lucas, S. & Crubezy, E. (2009). Dental caries, tooth wear and diet in adult medieval (12th-14th century) population from Mediterranean France. *Archives of Oral Biology, 54*(3), pp. 287-297. https://doi.org/10.1016/j.archoralbio.2008.11.004

Esclassan, R., Hadjouis, D., Donat, R., Passarrius, O., Maret, D., Vaysse, F., & Crubézy, E. (2015). A panorama of tooth wear during the medieval period. *Anthropologischer Anzeiger, 72 (2),* pp. 185-199. DOI: 10.1127/anthranz/2014/0442

Falys, C.G. & Prangle, D. (2015). Estimating Age of Mature Adults from the Degeneration of the Sternal End of the Clavicle. *American Journal of Physical Anthropology, 156(2),* 203-214. https://doi.org/10.1002/ajpa.22639

Fischler, C. (1988). Food, Self and Identity. *Social Science Information, 27(2),* 275-292. https://doi.org/10.1177/053901888027002005

Forshaw, R. J. (2014). Dental indicators of ancient dietary patterns: Dental analysis in archaeology. *British Dental Journal, 216,* 529-535. https://doi.org/10.1038/sj.bdj.2014.353

Forsåker, A. L. & Göthberg, H. (1986). *Stratigrafisk analyse. Delfelt FJ, FN og FW.* Fortiden i Trondheim bygrunn: Folkebibliotekstomten. Meddelelser nr. 7.

Fossheim, H. (2012). Introductory Remarks. In H. Fossheim (Ed.), *More than Just Bones: Ethics and Research on Human Remains.* (pp. 7-10). The Norwegian National Research Ethics Committees.

Fotakis, A. K., Denham, S. D., Mackie, M., Orbegozo, M. I., Mylopotamitaki, D., Gopalakrishnan, S., Sicheritz-Pontén, T., Olsen, J. P., Cappellini, E., Zhang, G., Christophersen, A., Gilbert, M. T. P. & Vågene, Å. J. (2020). Multi-omic detection of *Mycobacterium leprae* in archaeological human dental calculus. *Philosophical Transactions of the Royal Society B, 375 (1812): 20190584*. https://doi.org/10.1098/rstb.2019.0584

Ganss, C., Klimek, J. & Borkowski, N. (2002). Characteristics of tooth wear in relation to different nutritional patterns including contemporary and medieval subjects. *European Journal of Oral Sciences, 110*, pp. 54-60. https://doi.org/10.1034/j.1600-0722.2002.00117.x

Geber, J. & Murphy, E. (2012). Scurvy in the Great Irish Famine: Evidence of Vitamin C Deficiency from a Mid-19th Century Skeletal Population. *American Journal of Physical Anthropology, 148(4)*, 512-524. https://doi.org/10.1002/ajpa.22066

van Gerven, D. P., Beck, R. & Hummert, J. R. (1990). Patterns of enamel hypoplasia in two medieval populations from Nubia's Batn el Hajar. *American Journal of Physical Anthropology, 82,* pp. 413-420. https://doi.org/10.1002/ajpa.1330820403

Giddens, A. (1984). *The Constitution of Society Outline of the Theory of Structuration.* Berkeley, CA: University of California Press.

Goodman, A. H. (1993). On the Interpretation of Health from Skeletal Remains. *Current Anthropology, 34*(3): 281-288. DOI: 10.1086/204170

Goodman, A. H., Allen, L. H., Hernandez, G. P., Amador, A., Arriola, L. V., Chavez, A. & Pelto, G. H. (1987). Prevalence and Age at Development of Enamel Hypoplasias in Mexican Children. *American Journal of Physical Anthropology, 72*, pp. 7-19.

Goodman, A. H., Armelagos, G. J., & Rose, J. C. (1980). Enamel Hypoplasias as Indicators of Stress in Three Prehistoric Populations from Illinois. *Human Biology*, *52*(3), pp. 515–528. http://www.jstor.org/stable/41464558

Grenne, T., Heldal, T., Meyer, G. B., & Bloxam, E. G. G. (2008). From Hyllestad to Selbu: Norwegian millstone quarrying through 1300 years. In Slagstad, T. (ed.) *Geology for Society*, *Geological Survey of Norway Special Publication, 11*, pp. 47–66. From https://www.researchgate.net/publication/258780988_Norwegian_millstone_quarry_landscapes

Griffin, K. & Sandvik, P. U. (1989). *Frukter, frø og andre makrofossiler. Funksjoner og aktiviteter belyst gjennom analyser av jordprøver*. Fortiden i Trondheim bygrunn: Folkebibliotekstomten. Meddelelser nr. 19.

Grove, J. (2001). The initiation of the" Little Ice Age" in regions round the North Atlantic. *Climatic Change, 48(1),* 53-82. https://doi.org/10.1023/A:1005662822136

Güllü, S., Erdoğan, M.F., Uysal, A.R., Başkal, N., Kamel, A.N., & Erdogan, G. (1998). A potential risk for osteomalacia due to sociocultural lifestyle in Turkish women. *Endocrine journal, 45(5)*, 675-678. https://doi.org/10.1507/endocrj.45.675

Göthberg, H. (1986). Kyrkogården på Folkebibliotekstomten i Trondheim: Fasindelning. In T. Anderson & H. Göthberg (Eds.), *Olavskirkens kirkegård. Humanosteologisk analyse og faseinndeling*. Fortiden i Trondheim bygrunn: Folkebibliotekstomten. Meddelelser nr. 2.

Halvorsen, P. B. (2022, 21st of March). Tiggermunker. From https://snl.no/tiggermunker

Hanson, C. L. (1986). Biological Distance in Medieval Western Scandinavia Based on Craniometrics. PhD, Arizona State University.

Hanson, C. L. & Miller, H. S. (1997). LEHs in Medieval Scandinavia: Preliminary Analysis. *Dental Anthropology, 11(3)*, 9-12. https://doi.org/10.26575/daj.v11i3.210

Hamre, S. S. (2011). *Burial Practices in Early Christian Norway. An Osteoarchaeological Study Into Differences and Similarities Between Four Burial Assemblages.* (PhD, University of Bergen).

Hamre, S.S. & Daux, V. (2016). Stable oxygen isotope evidence for mobility in medieval and post-medieval Trondheim, Norway. *Journal of Archaeological Science: Reports, 8*, 416–425. https://doi.org/10.1016/j.jasrep.2016.06.046

Hamre, S. S. (2017). Skjeletter belyser trondheimshistorien. SPOR, 2.

Hamre, S.S., Ersland, G.A., Daux, V., Parson, W. & Wilkinson, C. (2017). Three individuals, three stories, three burials from medieval Trondheim, Norway. *PLoS ONE 12(7),* 1-26. https://doi.org/10.1371/journal.pone.0180277

Helama, S., M. Timonen, J. Holopainen, M. G. Ogurtsov, K. Mielikäinen, M. Eronen, M. Lindholm & J. Meriläinen. (2009). Summer temperature variations in Lapland during the Medieval Warm Period and the Little Ice Age relative to natural instability of thermohaline circulation on multi decadal and multi centennial scales. *Journal of Quaternary Science 24(5),* 450-456. https://doi.org/10.1002/jqs.1291

Hershkovitz, I., Latimer, B., Dutour, O., Ellema, L.M.J., Wish-Baratz, S., Rothschild, C., Rothschild, B.M. (1997). Why Do We Fail in Aging the Skull From the Sagittal Suture? *American Journal of Physical Anthropology, 103(3)*, 393–399. https://doi.org/10.1002/(SICI)1096-8644(199707)103:3<393::AID-AJPA8>3.0.CO;2-R

Hillson, S. W. (1979). Diet and Dental Disease. *World Archaeology*, *11*(2), 147–162. http://www.jstor.org/stable/124357

Hillson, S. (2001). Recording dental caries in archaeological human remains. *International Journal of Osteoarchaeology, 11(4),* 249-289. https://doi.org/10.1002/oa.538

Hodder, I., & Hutson, I. (2003). *Reading the past: Current approaches to interpretation in archaeology (3rd ed)*. Cambridge, UK: Cambridge University Press.

Holt, R. (2007). What if the Sea were Different? Urbanization in Medieval Norway. *Past & Present*, *195(2),* 132–147. https://doi.org/10.1093/pastj/gtm026

İşcan, Y., Loth, S.R. & Wright, R.K. (1984). Age Estimation from the Rib by Phase Analyses: White Males. *Journal of Forensic Sciences, 29(4)*, 1094-1104. From https://pubmed.ncbi.nlm.nih.gov/6502109/

İşcan, Y., Loth, S.R. & Wright, R.K. (1985). Age Estimation from the Rib by Phase Analyses: White Females. *Journal of Forensic Sciences, 30(3),* 853-863. From https://pubmed.ncbi.nlm.nih.gov/4031812/

Jantsch, A.K. (2017). *TA 2017/5 Dronningens gate 5, Britannia Hotel, Trondheim Arkeologisk undersøkelse av kulturlagsomfang og bevaringsforhold i bakgård i forbindelse med nybygg.* (NIKU Oppdragsrapport 46/2017). From https://niku.brage.unit.no/niku-xmlui/handle/11250/2583659

Jones, A. K. G. (1979). Parasite Remains from "Oslogate 7." In Schia, E., (ed.). *De Arkeologiske Utgravninger i Gamlebyen, Oslo: Feltene «Oslogate 3 og 7»* (Volume 2, pp. 138-139). Alvheim & Eide Akademiske Forlag: Øvre Ervik.

Key, C. A., Aiello, L. C., Molleson, T. (1994). Cranial suture closure and its implications for age estimation. *International Journal of Osteoarchaeology, 4(3),* 193-207. https://doi.org/10.1002/oa.1390040304

Koruyucu, M. M., & Erdal, Y. S. (2021). Reconstruction of dietary habits in the Early Bronze Age of Anatolia through the analysis of dental caries and wear. *International Journal of Osteoarchaeology*, 31(5), 902– 915. https://doi.org/10.1002/oa.3007

Kyllingstad, J.R. (2004). *Kortskaller og langskaller: fysisk antropologi i Norge og striden om det nordiske herremennesket*. Oslo: Scandinavian Academic Press.

Lamb, H. H. (1995). Climate, history and the modern world. London: Routledge.

Lamont, M., & Lareau, A. (1988). Cultural Capital: Allusions, Gaps and Glissandos in Recent Theoretical Developments. *Sociological Theory, 6(2),* 153-168. 10.2307/202113

de Lemps, A. H. (1999). Colonial Beverages and the Consumption of Sugar. In J-L. Flandrin, M. Montanari & A. Sonnenfeld. *Food: A culinary history from Antiquity to the present* (pp. 383-393). Columbia University Press: New York.

Lie, R. W. (1989). *Dyr i byen. En osteologisk analyse*. Fortiden i Trondheim bygrunn: Folkebibliotekstomten. Meddelelser nr. 18.

Lieverse, A. R. (1999). Diet and the aetiology of dental calculus. *International Journal of Osteoarchaeology, 9(4),* 219-232. https://doi.org/10.1002/(SICI)1099-1212(199907/08)9:4<219::AID-OA475>3.0.CO;2-V

Lin, H. K., Pan, Y. H., Salamanca, E., Lin, Y. T., & Chang, W. J. (2019). Prevention of Bone Resorption by HA/β-TCP + Collagen Composite after Tooth Extraction: A Case Series. *International journal of environmental research and public health*, *16*(23), 4616. https://doi.org/10.3390/ijerph16234616

Lips, P. (2001). Vitamin D Deficiency and Secondary Hyperparathyroidism in the Elderly: Consequences for Bone Loss and Fractures and Therapeutic Implications. *Endocrine Reviews, 22(4)*, 477-501. https://doi.org/10.1210/edrv.22.4.0437

Listi, G.A. & Bassett, E. (2006). Test of an Alternative Method for Determining Sex from the Os Coxae: Applications for Modern Americans*. *Journal of Forensic Sciences, 51(2)*, 248-252. https://doi.org/10.1111/j.1556-4029.2006.00080.x

Long, C.D. (1973). Excavations in Trondheim 1970 - 72. *Nicolay Oslo: Nicolay arkeologisk tidsskrift, 1973* (nr. 13), 30-35. From https://www.duo.uio.no/handle/10852/40317

Long, C.D. (1974): Utgravningen av en kirke i Trondheim. *Nicolay Oslo: Nicolay arkeologisk tidsskrift, 1974* (nr. 17), 22-31. From https://www.duo.uio.no/handle/10852/40374

Long, C.D. (1976): Søndregate, Trondheim. *Nicolay Oslo: Nicolay arkeologisk tidsskrift, 1976* (nr. 23), 26-28. From https://www.duo.uio.no/handle/10852/40381

Loth, S.R., İşcan, Y., & Scheuerman, E.H. (1994). Intercostal variation on the sternal end of the rib. Forensic Science International, 65(2), 135-143. https://doi.org/10.1016/0379-0738(94)90268-2

Lovejoy, C.O., Meindl, R.S., Pryzbeck, T.R., Mensforth, R.P. (1985). Chronological metamorphosis of the auricular surface of the ilium: A new method for the determination of adult skeletal age at death. American Journal of Physical Anthropology, 68(1): 15-28. https://doi.org/10.1002/ajpa.1330680103

Lukacs, J.R. (1992). Dental Paleopathology and Agricultural Intensification of South Asia: New Evidence from Bronze Age Harappa*. American Journal of Physical Anthropology, 87(2),* 133-150. https://doi.org/10.1002/ajpa.1330870202

Lukacs, J.R. (2007). Dental trauma and antemortem tooth loss in prehistoric Canary Islanders: prevalence and contributing factors. *International Journal of Osteoarchaeology, 17(2),* 157-173. https://doi.org/10.1002/oa.864

Lukacs, J.R., & Pal, J.N. (1993). Mesolithic Subsistence in North India: Inferences from Dental Attributes. *Current Anthropology, 34(5),* 745-765. http://www.jstor.org/stable/2744287

Lyman, R. L. (1994). Vertebrate Taphonomy. Columbia: Cambridge University Press.

Maat, G.J.R. (2001). Diet and age-at-death determinations from molar attrition. A review related to the low countries. *The Journal of forensic odonto-stomatology 19(1),* 18-21. From https://www.researchgate.net/publication/11849409_Diet_and_age-at-death_determinations_from_molar_attrition_A_review_related_to_the_low_countries

Maat, G.J.R. (2004). Scurvy in Adults and Youngsters: The Dutch Experience. A Review of the History and Pathology of a Disregarded Disease. *International Journal of Osteoarchaeology, 14(2)*, 77-81. https://doi.org/10.1002/oa.708

Malville, N.J. (1997). Enamel hypoplasia in ancestral Puebloan populations from southwestern Colorado: I. Permanent dentition. *American Journal of Physical Anthropology, 102 (3),* pp. 351-367. https://doi.org/10.1002/(SICI)1096-8644(199703)102:3<351::AID-AJPA5>3.0.CO;2-Y

Manji, F., Fejerskov, O. & Baelum, V. (1989a). Pattern of dental caries in an adult rural population. *Caries Research, 23*, pp. 55–62. DOI: 10.1159/000261155

Mant, M., & Roberts, C. (2015). Diet and Dental Caries in Post-Medieval London. *International Journal of Historical Archaeology, 19*, pp. 188-207. DOI: 10.1007/s10761-014-0286-x

May, R.L., Goodman, A. H. & Meidl, R. S. (1993). Response of bone and enamel formation to nutritional supplementation and morbidity among malnourished Guatemalan children. *American Journal of Physical Anthropology, 92,* pp. 37-51. From https://www.academia.edu/16942818/Response_of_bone_and_enamel_formation_to_nutritional_supplementation_and_morbidity_among_malnourished_Guatemalan_children

Melikian, M. & Waldron, T. (2003). An examination of skulls from two British sites for possible evidence of scurvy*. International Journal of Osteoarchaeology, 13(4):* 207-212. https://doi.org/10.1002/oa.674

Mitchell, P.D. (2015). Human parasites in medieval Europe: lifestyle, sanitation and medical treatment. *Advances in Parasitology, 90*, pp. 389-420. DOI: 10.1016/bs.apar.2015.05.001

Moen, U. (1971). Byen under gaten: Fra utgravingene i Søndre gate i årene 1970-71 (pp. 90- 102). Trondheim: Adresseavisens forlag. From https://www.nb.no/items/URN:NBN:nonb_digibok_2007072400122?page=0&searchText=grav

Moore, W. J. &, Corbett, M. E. (1971). The distribution of dental caries in ancient British populations. 1. Anglo-saxon period. *Caries Research, 5(*2), pp.151-68. DOI: 10.1159/000259743

Nagaoka, T., Seki, Y., Uzawa, K., Morita, W. & Chocano, D. M. (2021). Prevalence of dental caries and antemortem tooth loss at Pacopampa in an initial stage of social stratification in Peru’s northern highlands. *Anthropological Science, 129*(2), pp. 165-185. https://doi.org/10.1537/ase.210505

Nikiforuk, G. & Fraser, D. (1981). The etiology of enamel hypoplasia: A unifying concept. *The Journal of Pediatrics, 98(6),* 888-893. https://doi.org/10.1016/S0022-3476(81)80580-X

Nikita, E. (2017). Osteoarchaeology: A Guide to the Macroscopic Study of Human Skeletal Remains (pp. 77-90). Academic Press: London.

Nordeide, S.W. (1988). *Faseplaner*. Fortiden i Trondheim bygrunn: Folkebibliotekstomten. Meddelelser nr. 13, del 2.

NTNU University Museum. (2017). Medieval Urban Health- From Individual to Public Responsibility, AD 1000-1600 (MedHeal600). From https://www.ntnu.edu/museum/medieval-urban-health-from-individual-to-public-responsibility-ad-1000-1600-medheal600-

Næss, J-R. & Sellevold, B. J. (1990). Graver fra historisk tid: vitenskapelig kilde og forvaltningsproblem med spesiell vekt på 'kristne graver' fra middelalderen. Collegium Medievale, 3, Supplement, 1-40.

Ortner, S. B. (1984). Theory in anthropology since the sixties. *Comparative Studies in Society and History, 26(1),* 126–166. https://www.jstor.org/stable/178524

Ortner, D.J. & Putschar, W.G.J. (1981). *Identification of Pathological Condition in Human Skeletal Remains (28,* pp. 251-257, 270-283, 438-439, 454*)*. Washington D.C: Smithsonian Institution Press.

Oxenham, M.F. & Cavill, I. (2010). Porotic hyperostosis and cribra orbitalia: the erythropoietic response to iron-deficiency anaemia. *Anthropological Science, 118*(3), 199-200. https://doi.org/10.1537/ase.100302

Palubeckaité, Z., Jankauskas, R., & Boldsen, J. (2002). Enamel Hypoplasia in Danish andLithuanian Late Medieval/Early Modern Samples: a Possible Reflection of Child Morbidity and Mortality Patterns. *International Journal of Osteoarchaeology, 12*, pp. 189-201. DOI: 10.1002/oa.607

Perizonius, W.R.K. (1984). Closing and non-closing sutures in 256 crania of known age and sex from Amsterdam (A.D. 1883–1909). *Journal of Human Evolution, 13(2),* 201-2016. https://doi.org/10.1016/S0047-2484(84)80065-2

Petersén, A. H., Sandvik, U. P., & Sveistrup, T.E. (2015). The rural–urban connection as revealed in the terrestrial sediments at Nidarneset, Trondheim, Norway. *Journal of Archaeological Science, 2*, 389-404. https://doi.org/10.1016/j.jasrep.2015.03.008.

Phenice, T.W. (1969). A newly developed visual method of sexing the os pubis. *American Journal of Physical Anthropology, 30,* 297-301. https://doi.org/10.1002/ajpa.1330300214

Ramstad, S. (2002). *"Gregoriuskirka": Rekonstruksjon og funksjonell analyse* (Master thesis). NTNU: Trondheim.

Reckwitz, A. (2002). Toward a Theory of Social Practices. *European Journal of Sociology*, *5*(2), 243–263. https://doi.org/10.1177/13684310222225432

Reed, I., Kockum, J., Hughes, K., Sandvik, P. U. (1998). Excavations outside the west front of Nidaros Cathedral in Trondheim. NIKU Oppdragsmelding 055. NIKU, Trondheim.

Richer, S., Allison, E., Morandi, L., Adams, S., & Allott, L. (2020). *Torvet, Trondheim, Norway: Pollen, Non-Pollen Palynomorphs, Insect, Parasite Eggs, Macrofossils Analyses Report.* Quaternary Scientific (Quest), University of Reading. [Unpublished report].

Richter, S. & Eliasson, S. T. (2016). Possible Causes of Tooth Wear in Medieval Icelanders. *Universal Journal of Medical Science, 4*(3), pp. 94-101. DOI: 10.13189/ujmsj.2016.040303

Roberts, C. & Manchester, K. (2007). *The Archaeology of Disease*. Cornell University Press: New York.

Rugg-Gunn, A. J., & Nunn, J. H. (1999). *Nutrition, diet, and oral health*. Oxford [England]: Oxford University Press.

Sandvik, P. U. & Selvik, S. F. (1999). Frå Nidarnes til Nidaros – plantene fortel historia. In L. Selsing & G. Lillehammer (eds.), *Museumslandskap: Artikkelsamling til Kerstin Griffin på 60-årsdagen* (pp. 79-88). AmS-Rapport 12A. Stavanger: Arkeologisk museum i Stavanger.

Scheuer, J.L., Musgrave, J.H., & Evans, S.P. (1980). The estimation of late fetal and peri-natal age from limb bone length by linear and logarithmic regression. *Annals of Human Biology, 7*(3), 257-265. https://doi.org/10.1080/03014468000004301

Schrader, S. (2019). *Activity, Diet and Social Practice: Addressing Everyday Life in Human Skeletal Remains*. Springer Nature Switzerland AG 2019. From https://doi.org/10.1007/978-3-030-02544-1

Sellevold, B. J. (1990). Skjelettene i biblioteket: Olavskirken, Folkebiblioteket, Trondheim (Arkeologiske undersøkelser i Trondheim nr. 4). Trondheim: Riksantikvaren.

Sellevold, B.J. (2006). *Forvaltning av graver og skjeletter fra nyere tid Rapport til Riksantikvaren* (NIKU Arkeologiske utgravninger. Antropologiske undersøkelser rapport nr. 7 – 2006). From https://ra.brage.unit.no/ra-xmlui/handle/11250/176258

Sellevold, B. J. (2011). Norway. In N. Marquez-Grant & L. Fibiger (eds.), *The Routledge Handbook of Archaeological Human Remains and Legislation An international guide to laws and practice in the excavation and treatment of archaeological human remains* (pp. 314– 328). Routledge.

Sellevold, B. J. (2014). From physical anthropology to osteoarchaeology. In B. J. Sellevold (ed.), Old Bones: osteoarchaeology in Norway: yesterday, today and tomorrow (pp. 17-36). Oslo: Novus Forlag.

Selvik, S. F. (1986). *Naturforhold på Nidarneset: En vegetasjonshistorisk rekonstruksjon.* Fortiden i Trondheim bygrunn: Folkebibliotekstomten. Meddelelser nr. 6.

Shove, E., Pantzar, M., & Watson, M. (2012). *The Dynamics of Social Practice: Everyday Life and How it Changes.* Sage publications Ltd.

Siek, T. (2013). The Osteological Paradox and Issues of Interpretation in Paleopathology. *vis-à-vis: Explorations in Anthropology, 13*, pp. 92-101.

Singh, S. & Potturi, B.R. (1977). Greater Sciatic Notch in sex determination. *Journal of Anatomy, 125(3),* 619-624. From https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1235628/?page=1

Skinner, M. & Goodman, A. (1992). Anthropological uses of develop-mental defects of enamel. In: S. Saunders & M.A. Katzenberg (Ed.), *Skeletal Biology of Past: Advances in Research Methods* (153-174). New York: Wiley- Liss.

Smith, B. (1984). Patterns of molar wear in hunger-gatherers and agriculturalists. *American journal of physical anthropology, 63 1*, 39-56. https://doi.org/10.1002/ajpa.1330630107

Stevenson, P.H. (1924). Age order of epiphyseal union in man. *American Journal of Physical Anthropology, 7,* 53-93. https://doi.org/10.1002/ajpa.1330070115

Stothers, R.B. (2000). Climatic and Demographic Consequences of the Massive Volcanic Eruption of 1258. *Climatic Change, 45,* 361-374. https://doi.org/10.1023/A:1005523330643

Stuart-Macadam, P. (1985). Porotic hyperostosis: representative of a childhood condition. *American Journal of Physical Anthropology 66(4),* 391-398. https://doi.org/10.1002/ajpa.1330660407

Stuart-Macadam, P. (1987). Porotic Hyperostosis: New Evidence to Support the Anemia Theory. *American Journal of Physical Anthropology, 74(4)*, 521-526. https://doi.org/10.1002/ajpa.1330740410

Stuart-Macadam, P. (1989). Porotic Hyperostosis: Relationship Between Orbital and Vault Lesions. *American Journal of Physical Anthropology, 80(2)*, 187-193. https://doi.org/10.1002/ajpa.1330800206

Stuart-Macadam, P. (1992). Porotic Hyperostosis: A New Perspective. *American Journal of Physical Anthropology, 87(1)*, 39-47. https://doi.org/10.1002/ajpa.1330870105

Sæhle, I., Petersén, A., Wood, P.N., Brink, K., Valstrand, N.E, & Lorvik, K. (2021). *Arkeologiske undersøkelser i Søndre gate 7-11, Peter Egges plass, Krambugata 2-4 m.fl., Trondheim, Trøndelag (TA 2016/21, TA 2017/03): Landskapsutvikling, tidlig urban aktivitet og middelaldersk kirkested* (NIKU, rapport nr. 97). From https://niku.brage.unit.no/niku-xmlui/handle/11250/2763893

Söderberg, J. (2015). Oceanic thirst? Food consumption in mediaeval Sweden. *Scandinavian Economic History Review, 63(2)*, pp.135-153. DOI: 10.1080/03585522.2014.987315

Takahashi, H. (2006). Curvature of the Greater Sciatic Notch in Sexing the Human Pelvis. *Anthropological Science, 114(3)*, 187-191. From https://doi.org/10.1537/ase.051111

Thun, T. & Svarva, H. (2018). Tree-ring growth shows that the significant population decline in Norway began decades before the Black Death. *Dendrochronologia, 47*, 23-29.

Tomczyk, J., Szostek, K., Komarnitki, I., Mańkowska-Pliszka, H., Zalewska, M. (2013). Dental caries and chemical analyses in reconstruction of diet, health and hygienic behaviour in the Middle Euphrates valley (Syria). *Archives of Oral Biology, 58(6),* 740-51. https://doi.org/10.1016/j.archoralbio.2012.12.014

Ubelaker, D. H. (2005). Estimating Age at Death. In J. Rich, D. E. Dean, & R. H. Powers, *Forensic Medicine of the Lower Extremity: Human Identification and Trauma Analysis of the Thigh, Leg, and Foot* (pp.99-112)*.*Totowa, New Jersey: Humana Press.

Umapathy, T., Jayam, C., Yogish, P., Yogish, A., Bandlapalli, A. (2013). Linear Enamel Hypoplasia. *Journal of Indian Academy of Oral Medicine and Radiology, 25(2),* 0-0. From https://www.researchgate.net/publication/281242338_Linear_Enamel_Hypoplasia

Valstrand, N. E. (2022). *Biographies of the dead. The correlation of occlusal wear rate and skeletal age markers in the medieval Nidaros population* [doctoral thesis in preparation]. Department of Historical and Classical Studies, Norwegian University of Science and Technology.

Vedeler, M. (2017). Fra kokebøker til matrester i middelalderbyen (Cookbooks and food remains in the medieval towns of Norway). *Primitive Tider, 19,* pp. 61-77.

Vercellotti, G., Piperata, B.A., Agnew, A.M., Wilson, W.M., Dufour, D.L., Reina, J.C., Boano, R., Justus, H.M., Larsen, C.S., Stout, S.D. and Sciulli, P.W. (2014), Exploring the multidimensionality of stature variation in the past through comparisons of archaeological and living populations. *American Journal of Physical Anthropology, 155*, 229-242. https://doi.org/10.1002/ajpa.22552

Walker, P.L., Bathurst, R.R., Richman, R., Gjerdrum, T. & Andrushko, V.A. (2009). The causes of porotic hyperostosis and cribra orbitalia: A reappraisal of the iron-deficiency-anemia hypothesis. *American Journal of Physical Anthropology, 139(2)*, 109-125. https://doi.org/10.1002/ajpa.21031

Whittaker, D. K., Molleson, T., Bennet, R. B., Edwards, I., Jenkins, P R., Llewelyn, J. H. (1981). The prevalence and distribution of dental caries in a Romano-British population. *Archives of Oral Biology, 26*(3), pp. 237-245. https://doi.org/10.1016/0003-9969(81)90136-9

Wood, L. (1996). Frequency and chronological distribution of linear enamel hypoplasia in a North American colonial skeletal sample. American Journal of Biological Anthropology, 100 (2), pp. 247-259. https://doi.org/10.1002/(SICI)1096-8644(199606)100:2<247::AID-AJPA6>3.0.CO;2-U

Wood, J. W., Milner, G. R., Harpending, H. C. & Weiss, K. M. (1992). The Osteological Paradox: Problems of Inferring Prehistoric Health from Skeletal Samples. *Current Anthropology, 33*(4), 343–370. http://www.jstor.org/stable/2743861

Woolgar, C. M. (2010) Food and the middle ages. *Journal of Medieval History*, *36(1),* 1-19. 10.1016/j.jmedhist.2009.12.001

Wright, L.E. & Chew, F. (1998). Porotic Hyperostosis and Paleoepidemiology: A Forensic Perspective on Anemia among the Ancient Maya. *American Anthropologist, 100*, pp. 924-939. https://doi.org/10.1525/aa.1998.100.4.924

Yoder, C., Ubelaker, D.H., & Powell, J.F. (2001). Examination of variation in sternal rib end morphology relevant to age assessment. *Journal of forensic sciences, 46 2*, 223-227. DOI: 10.1520/JFS14953J

Zhou, L. & Corruccini, R.S. (1998). Enamel hypoplasias related to famine stress in living Chinese. *American Journal of Human Biology, 10,* pp. 723-733. https://doi.org/10.1002/(SICI)1520-6300(1998)10:6<723::AID-AJHB4>3.0.CO;2-Q

Øye, I. (1998). *Middelalderbyens agrare trekk.* Bergen: Bryggens museum.

Appendix. 1: Chosen Individuals Based on the Initial Recording Sheets

The Library Site

N-number	Skeletal ID	Field	Phase	Sex	Age	Notes
N88829	SKJ129	FN	B	F	25-35	South FN, 95% skeleton.
N88844	SKJ137	FN	B	F	30-35	South FN, 95% skeleton.
N88863	SKJ146	FN	6_7	F	23-30	Middle, 60% skeleton.
N89783	SKJ152	FN	A	F	19-24	West FN, 95% skeleton.
N89815	SKJ162	FN	6_7	F	23-28	South FN, 70% skeleton.
N91186	SKJ177	FN	B	F	35-50	Middle FN, 90% skeleton.
N91211	SKJ187	FN	6_7	F	23-32	Middle, 85% skeleton.
N91215	SKJ188	FN	6_7	F	20-25	South FN, 75% skeleton.
N91849	SKJ207	FN	6_7	F	35-50	Middle, 85% skeleton.
N91850	SKJ208	FN	6_7	M	35-45	South FN, 80% skeleton.
N92121	SKJ223	FN	6_7	F?	30-45?	Middle FN, 60% skeleton.
N92125	SKJ225	FN	6_7	M	30-35	Middle FN, 90% skeleton.
N92130	SKJ227	FN	6_7	F	18-24	Middle FN, 85% skeleton.
N92765	SKJ238	FN	6_7	M	ca. 20	Middle FN, 80% skeleton.
N93064	SKJ257	FN	A	M	35-50	West FN, 95% skeleton.
N93074	SKJ259	FN	7	M	25-35	Layer of wooden splinters, 90% skeleton. Arthritis.
N93360	SKJ268	FN	6_7	F?	35-45/Younger	90% skeleton.
N93716	SKJ298	FN	B	M	27-32	North FN, 95% skeleton.
N93719	SKJ299	FN	6_7	M	27-32	South FN, 50% skeleton.
N94222	SKJ317	FN	6	F?	20-25	West FN, 80% skeleton
N94223	SKJ318	FN	7	M	20-25	Layer of wooden splinters, 80% skeleton.
N94538	SKJ328	FN	6	M	23-28/40-50	West FN, 90% skeleton.
N94768	SKJ332	FN	6	F?	35-45?	West FN, 90% skeleton.
N94769	SKJ333	FN	4_5	F	22-27	Coffin.
N94936	SKJ340	FN	4_5	F	28-33	Fragmentation.
N95419	SKJ351	FN	B	M	21-26	North FN, 95% skeleton.
N95420	SKJ352	FN	B	F	30-35	North FN, 90% skeleton.
N96225	SKJ356	FN	6_7	F?	20-25	Middle FN, 95% skeleton.
N96226	SKJ357	FN	6_7	M	32-37	Middle FN, 65% skeleton.
N96653	SKJ381	FN	6_7	M	21-26	South FN, 60% skeleton.

Søndre gate

N-number	Skeletal ID	Field	Year of excavation	Sex	Age	Notes
N184	SKJ7	AM	1972	M	19-50	
N2330, N2331, N3051	SKJ31	AM	1972	M	19-50	
N209	SKJ38	AM	1972	M	19-50	
N2328, N2329, N2480, N2481, N2655	SKJ68	AM	1972	M	19-50	Good preservation
N23418, N23678, N23994, N24335, N24443	SKJ10	AS	1972	F	19-50	
N24638	SKJ14	AS	1972	M?	19-50	Cranium is good preserved
N23930, N23931, N23942, N24165, N24167	SKJ98	AS	1972	M	19-50	
N27413	SKJ159	AS	1972	F	19-50/50+	Foot crushed under a church wall?
N2640, N3593	SKJ4	AØ	1972	F	19-50	Enamel hypoplasia
N2415	SKJ8	AØ	1972	F?	19-50	Burned skull?
N2415, N2643, N3062	SKJ9	AØ	1972	F?	19-50	
N207060	SKJ IX	S	1971	F	YA	Crooked back? Extreme tar-tar
N12054, N12056	SKJ XI	S	1971	F	19-50	
N12081	SKJ XXII	S	1971	M	19-50	
N12085, N12086	SKJ XXVI	S	1971	F	19-50 (27?)	Good preservation
N12087	SKJ XXVII	S	1971	M	19-50/50+	Traces of healed cribra or-bitalia
N12098, N12100	SKJ XXXIV	S	1971	F	19-50	
N12101	SKJ XXXV	S	1971	M	19-50	
N12105, N12106	SKJ XXXVIII	S	1971	F	19-50	
N12111, N12112	SKJ XLIII	S	1971	F	19-50	Porous and healed/broken mandible?
N12127	SKJ LIV	S	1971	M	19-50	Good preservation
N12129	SKJ LVI	S	1971	M?	19-50	Cranium painted "love, peace.."?
N12141	SKJ LXIV	S	1971	F	19-50	Remarks on vertebrae?
N12143	SKJ LXVIII	S	1971	M	19-50/50+	Scurvy and/or osteomalacia?

Appendix. 2: An Overview of the Individuals Assessed from The Library Site

P: Present

N.O: Not observable

N-Number	Skeletal ID	Field	Complete.	Frag.	Surface preserv.	Sex	Age	CO	PH	Dental wear	Abscess	Calculus	Caries	LEH	AMTL
N88829	SKJ129	FN	75-100%	some	good	F	MA		P	P (14/32 teeth)	P	P			
N88844	SKJ137	FN	75-100%	some	good	F	MA			P (7/24 teeth)	P	P			
N88863	SKJ146	FN	50-75%	a lot	adequate	F?	YA		P	P (9/32 teeth)		P			
N89783	SKJ152	FN	75-100%	little	good	F	YA		P	P (11/32 teeth)		P			
N89815	SKJ162	FN	75-100%	a lot	adequate	F	YA	P	P	P (10/30 teeth)		P			
N91186	SKJ177	FN	75-100%	little	good	F	MA	N.O	N.O	N.O	P	N.O	N.O	N.O	P
N91211	SKJ187	FN	75-100%	some	good	F	YA	P	P	P (7/32 teeth)					
N91215	SKJ188	FN	75-100%	some	adequate	F?	YA	P		P (15/30 teeth)			P		
N91849	SKJ207	FN	75-100%	some	good	F?	MA	P	P	P (7/32 teeth)	P				P
N91850	SKJ208	FN	50-75%	a lot	bad	M	MA			P (7/28 teeth)	P	P		P	P
N92121	SKJ223	FN	50-75%	some	adequate	F	YA			P (3/28 teeth)	P	P			P
N92125	SKJ225	FN	75-100%	little	good	M	MA		P	P (12/32 teeth)		P			
N92130	SKJ227	FN	75-100%	little	good	F	YA	P	P	P (23/32 teeth)		P			
N92765	SKJ238	FN	75-100%	some	adequate	I	YA	P	P	P (25/32 teeth)		P	P	P	
N93064	SKJ257	FN	75-100%	little	good	M?	MA		P	P (17/32 teeth)	P	P			P
N93074	SKJ259	FN	75-100%	little	good	M	YA	P	P	P (12/32 teeth)		P			
N93360	SKJ268	FN	75-100%	little	good	F?	YA	P	P	P (13/32 teeth)	P	P			P
N93716	SKJ298	FN	75-100%	little	good	M	YA	P	P	P (16/32 teeth)		P		P	
N93719	SKJ299	FN	50-75%	a lot	bad	M?	MA	N.O	P	P (5/14 teeth)					
N94222	SKJ317	FN	75-100%	a lot	good	F	MA	P	P	P (12/32 teeth)		P			
N94223	SKJ318	FN	75-100%	some	good	I	YA	P	P	N.O	N.O	N.O	N.O	N.O	N.O
N94538	SKJ328	FN	75-100%	little	good	M	MA	N.O	P	P (12/32 teeth)					P
N94768	SKJ332	FN	75-100%	little	adequate	F?	MA		P	P (3/32 teeth)	P				P
N94769	SKJ333	FN	25-50%	a lot	bad	F	YA			P (8/31teeth)					
N94936	SKJ340	FN	50-75%	some	adequate	F	MA	P		P (9/32 teeth)					
N95419	SKJ351	FN	75-100%	little	good	M	YA	P	P	P (11/32 teeth)		P	P		
N95420	SKJ352	FN	75-100%	little	good	F	YA		P	P (14/32 teeth)		P	P		
N96225	SKJ356	FN	75-100%	some	good	F	YA	P	P	P (13/32 teeth)		P	P	P	
N96226	SKJ357	FN	50-75%	a lot	adequate	M	YA	P	P	P (9/30 teeth)				P	
N96653	SKJ381	FN	50-75%	a lot	adequate	M	MA	P	P	P (only 3 teeth)	N.O	P		P	N.O

Appendix. 3: Overview of the Individuals Assessed from Søndre gate

P: Present

N.O: Not observable

N-Number	Skeletal ID	Field	Complete.	Frag.	Surface preserv.	Sex	Age	CO	PH	Dental wear	Abscess	Calculus	Caries	LEH	AMTL
N184	SKJ7	AM	50-75%	a lot	bad	M?	MA	P		P (10/32 teeth)		P	P		
N2330, N2331, N3051	SKJ31	AM	75-100%	little	good	M	YA			P (21/28 teeth)		P		P	
N209	SKJ38	AM	75-100%	little	good	M	MA		P	P (23/30 teeth)	P			P	P
N2328, N2329, N2480, N2481, N2655	SKJ68	AM	75-100%	little	good	M	MA		P	P (29/32 teeth)			P	P	P
N23418, N23678, N23994, N24335, N24443	SKJ10	AS	75-100%	a lot	bad	F	YA		P	P (22/30 teeth)		P		P	
N24638	SKJ14	AS	0-25%	little	good	F?	YA	P	P	P (30/31 teeth)		P	P	P	
N23942, N24165, N24167	SKJ98	AS	75-100%	some	good	M	MA	P		P (26/32 teeth)		P	P		
N27413	SKJ159	AS	75-100%	some	good	F	MA		P	P (30/32 teeth)	P	P		P	P
N2640	SKJ4	AØ	75-100%	some	good	F	YA		P	P (24/32 teeth)		P		P	
N2415, N2643, N3062	SKJ8	AØ	25-50%	a lot	good	M?	MA	P		P (28/32 teeth)		P	P	P	P
N2415, N2643, N3062	SKJ9	AØ	25-50%	a lot	bad	F?	MA	N.O	N.O	P (10/16 teeth)		P			
N207060, 207061	SKJ IX	S	50-75%	some	good	F?	YA		P	P (24/32 teeth)		P	P	P	
N12054, N12056	SKJ XI	S	75-100%	some	good	F	YA		P	P (21/32 teeth)		P	P		
N12081	SKJ XXII	S	75-100%	some	good	M	MA	P	P	P (17/32 teeth)	P	P	P	P	P
N12085, N12086	SKJ XXVI	S	50-75%	some	adequate	F	MA		P	P (4/32 teeth)	P	P			P
N12087	SKJ XXVII	S	75-100%	little	good	M	MA	P	P	P (2/32 teeth)					P
N12098, N12099, N12100	SKJ XXXIV	S	25-50%	a lot	adequate	F?	MA	P	P	P (12/32 teeth)	P		P		
N12101	SKJ XXXV	S	75-100%	little	good	M	YA		P	P (25/32 teeth)	P		P	P	P
N12105, N12106	SKJ XXXVIII	S	50-75%	some	good	F	YA	P		P (21/31 teeth)		P	P	P	P
N12105, N12106	SKJ XXXVIII	S	25-50%	some	adequate	I	Infant	N.O	N.O	N.O	N.O	N.O	N.O	N.O	N.O
N12111, N12112	SKJ XLIII	S	50-75%	some	good	F	MA			P (17/32 teeth)	P	P			P
N12127	SKJ LIV	S	0-25%	little	good	I	?	N.O	N.O	P (only 2 teeth)	N.O	N.O	N.O	N.O	N.O.
N12129	SKJ LVI	S	75-100%	little	good	M	MA		P	P (18/30 teeth)	P	P			
N12141	SKJ LXVI	S	75-100%	little	good	F	YA	P	P	P (22/31 teeth)		P	P	P	
N12143	SKJ LXVIII	S	75-100%	some	good	M?	YA	P	P	P (14/32 teeth)	P	P		P	P
12161	SKJ LXXXV	S	25-50%	some	good	I	Infant	N.O	N.O	N.O	N.O	N.O	N.O	N.O	N.O
N12162	SKJ LXXXVI	S	25-50%	some	good	I	Infant	N.O	N.O	N.O	N.O	N.O	N.O	N.O	N.O

NTNU

Kunnskap for en bedre verden